

**Dynam**

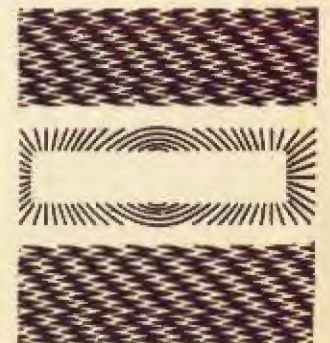
**ELECTRIKIT**

# INSTRUCTION

# MANUAL



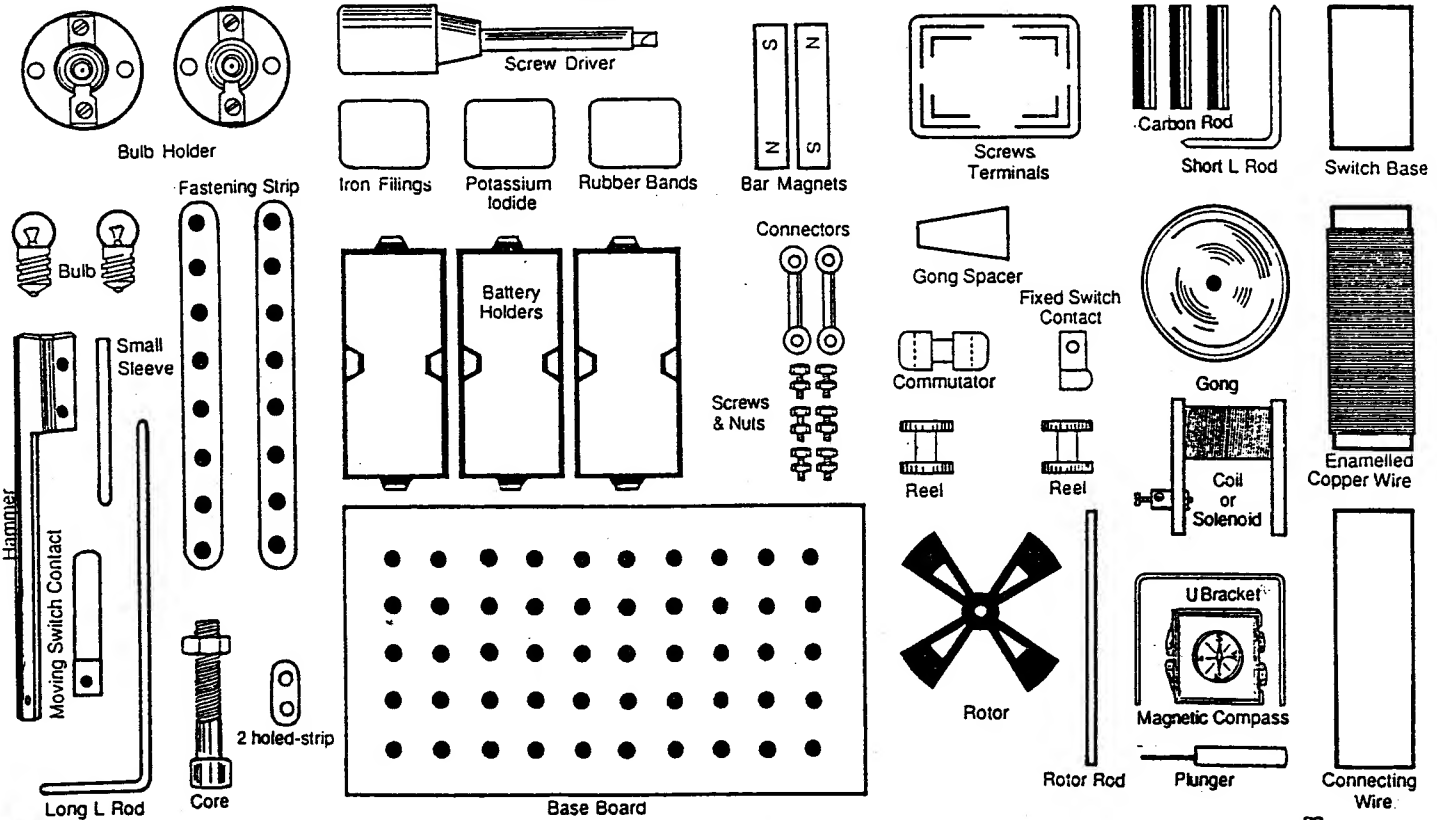
OVER SIXTY educational  
electrical experiments  
which you can do yourself



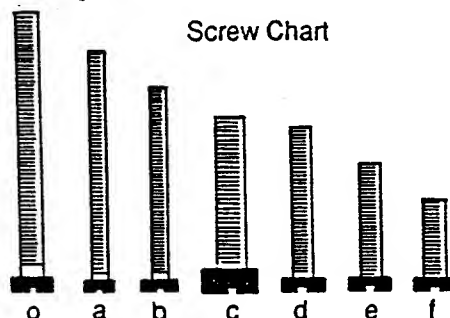
provides a *Dynamic* method of play-way in education

Syred 5.10.2013

## COMPONENT CHART



### Screw Chart



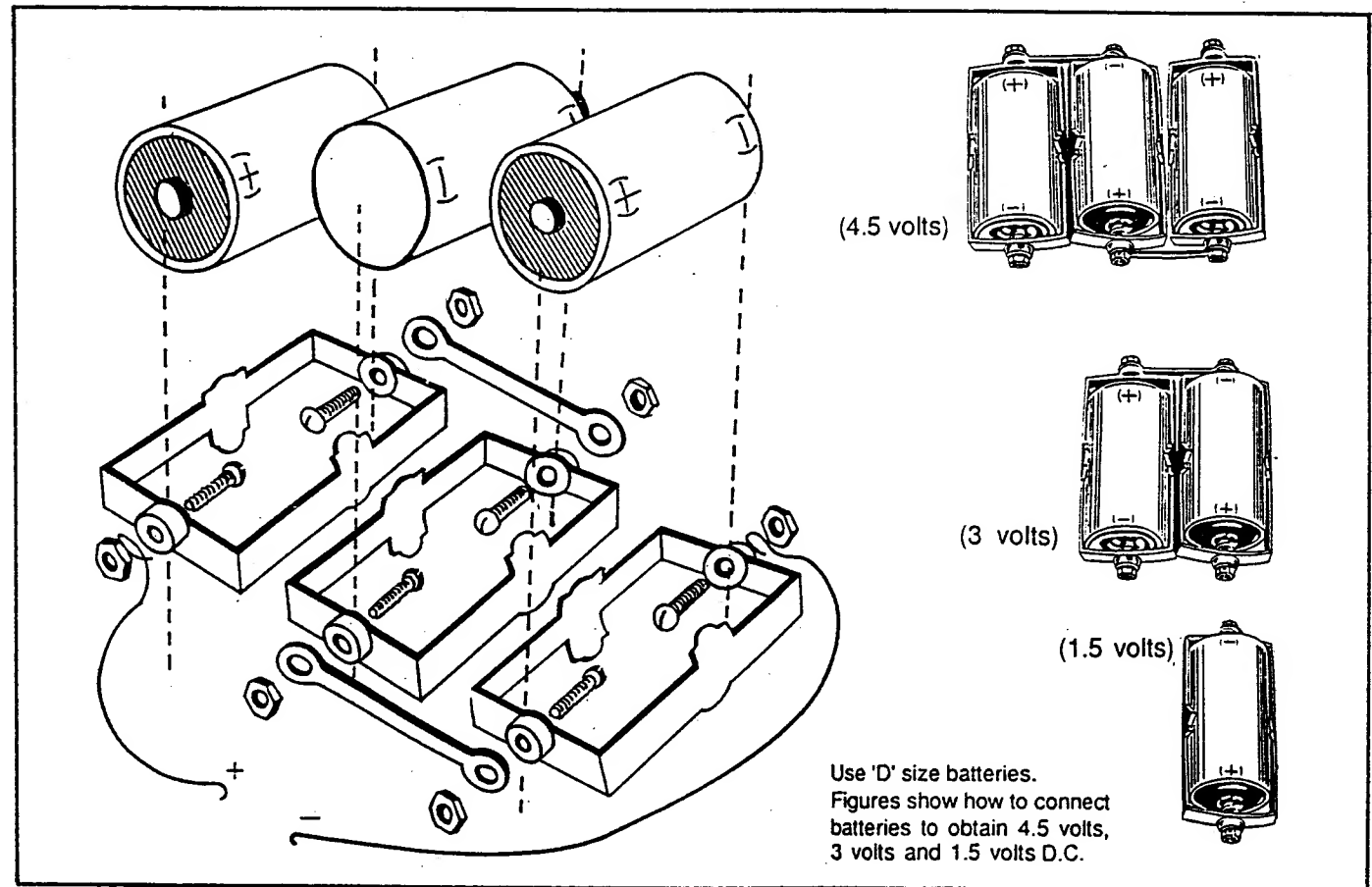
Rubber bands are provided in plastic box to enable you to keep together the loose bits of enamelled and connecting wires after use in the experiments.

Details of screws used in experiments may be had from the screw chart. Screws are printed to actual size in the chart.

Parts under baseboard :

Contact wire (2 rolls), Diaphragm, Scotchtape, Moving switch contact (extra), Sand paper (medium grade), Paper clips, Enamelled wire lengths, Index card (Quiz card), Fastening strips (extra).

The Meter Scale and Details of Lengths referred to, in experiments are available on the last page of the instruction manual.



Attention: Students, Parents & Guardians!  
Do not connect wires to wall socket. This can be  
extremely dangerous and can result in electrocution.

Caution : While handling rotor rod, L rods, etc.  
especially in passing the sleeves through these rods,  
do not use excessive force, since this can cause  
injury.

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## GENERAL INSTRUCTIONS

The experiments 1 to 60 in the Instruction Manual have been progressively graded. Proceed with the experiments in this order. Do not dismantle assemblies before verifying their use in successive experiments.

Handle all parts very carefully. In particular, do not drop the magnets, Compass, bulbs or the solenoid.

Do not operate on the battery for more than a few seconds in each experiment.

Do not bring the magnetic compass near the magnets as this may result in demagnetisation or reversal of polarity of the needle.

Do not tighten screw 'e' excessively when fastening the coil to the baseboard. Do not throw away bits of enamelled wire, connecting wire, and sleeves as these are used repeatedly.

Plan the electrical connections before fixing the components in place so that the connection between components is easy.

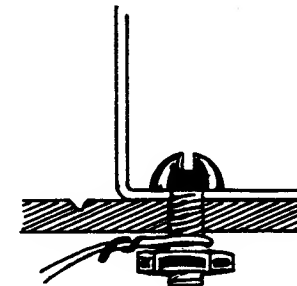
In all experiments on Magnetism in general, and with the Galvanometer in particular, take care to see that there are no iron or steel parts nearby.

As far as possible, devices like the motor, etc., should be oiled at the bearing surfaces to offer the least friction.

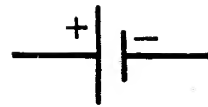
The schematic diagrams accompanying the experiments are generally indicated with switch ON. In particular cases, schematic diagrams show the switch OFF. In experiment 60 the wire length to be pushed into the central hole after passing the wire through the commutator holes may be adjusted to provide a fairly tight fit of the commutator on the shaft. Connection with enamelled wire should always be made after the insulation on the wire is removed at the points of connection.

Connection to screw is made under the baseboard by forming the wire into a loop which is held between the baseboard bottom and nut.

The accompanying figure shows details.



# Symbols for Schematic Diagrams



BATTERY



BULB



DIRECTION OF CURRENT FLOW



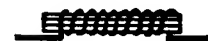
SWITCH—ON



SWITCH—OFF



SOLENOID



SOLENOID WITH CORE--> ELECTROMAGNET



GALVANOMETER



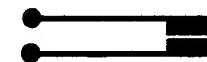
METER



RESISTANCE



CONTACTS CLOSED



CONTACTS OPEN



COMMUTATOR

## EXPERIMENT 1

Parts : Bulb, Bulb holder, Connecting Wires, Battery (3 volts)

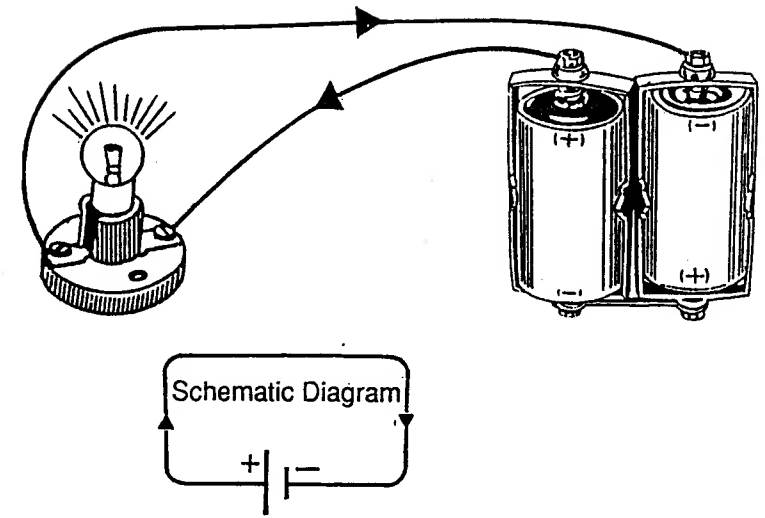
### A Simple Electric Circuit

Screw the bulb into the bulb holder. Connect the bulb to the battery, as in fig. 1.

The current flows from the positive to the negative terminal of the battery through the bulb filament and the bulb glows.

Disconnect the battery. The bulb goes off because there is no current flow through the bulb filament.

Fig 1



## EXPERIMENT 2

Parts : Bulb, Bulb holder, Switch base, Fixed switch contact, Moving switch contact, Connecting wires, Battery (3 volts)  
Screw 'a' --> (2)

### The Switch

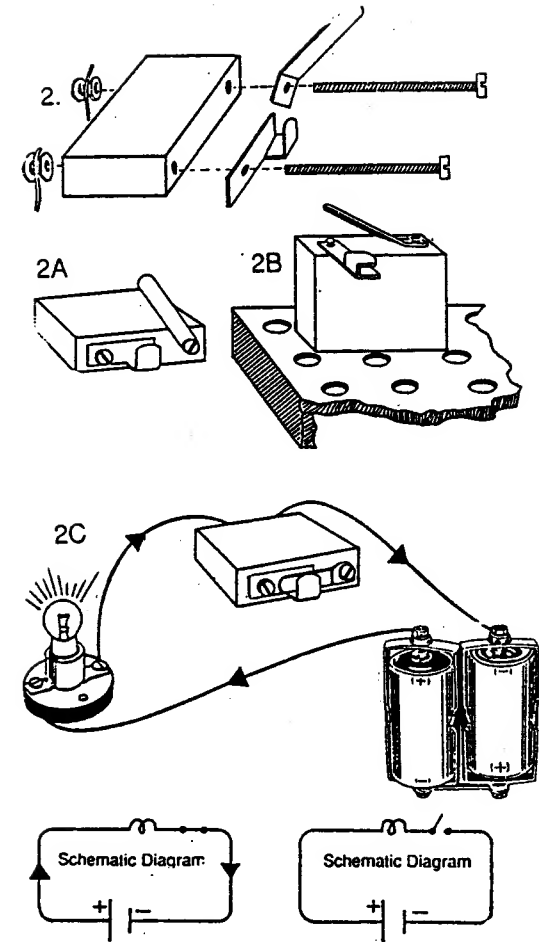
Assemble the switch with the switch base, moving switch contact and the fixed switch contact per fig. 2.

Fig. 2a shows the assembly as a switch, fig. 2b as a switch key, on the baseboard.

Connect the bulb to the battery through the switch, as shown in the figure.(2c)

The bulb can be switched 'on' and 'off' using the switch. When the switch is 'on', the electric current flows through the bulb and the bulb glows.

When 'off', the moving contact is not in touch with the fixed contact, the circuit is broken and the current cannot flow through the bulb.





### EXPERIMENT 3

Parts : Bulb, Bulb holder, Fastening strip, Long L rod, Enamelled wire—2" length, Connecting wires, Battery (3 volts), sand paper (under baseboard)

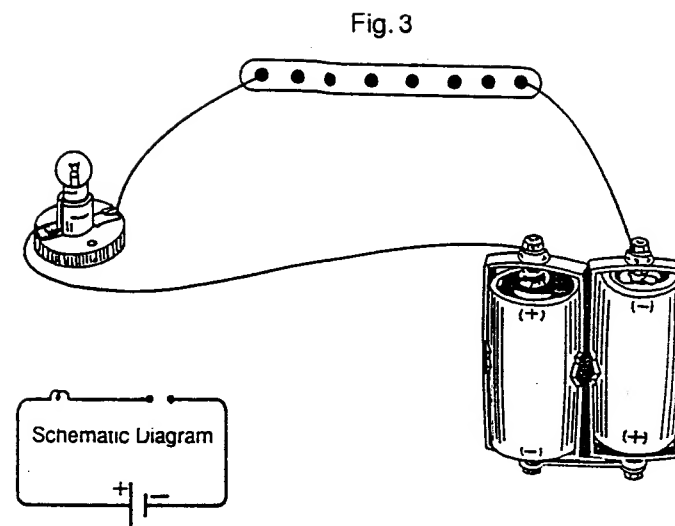
#### Conductors and Insulators

Connect the bulb to the battery through the fastening strip as shown. The bulb does not glow. This shows that the material of the strip (plastic) is an insulator. i.e. it prevents the flow of current.

Replace the strip by the long L rod. The bulb glows. This shows that the material of the L rod is a conductor. i.e. it allows the flow of current.

Replace the L rod with the enamelled wire. The bulb does not glow. Scrape the insulation thoroughly from the wire ends using sand paper. Connect again. The bulb now glows.

**In making connections with enamelled wire, the enamel must be removed at the points of connection.**



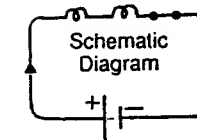
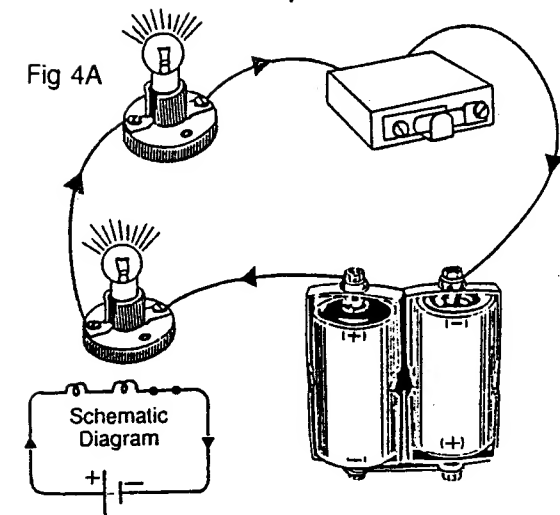
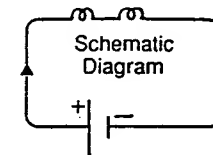
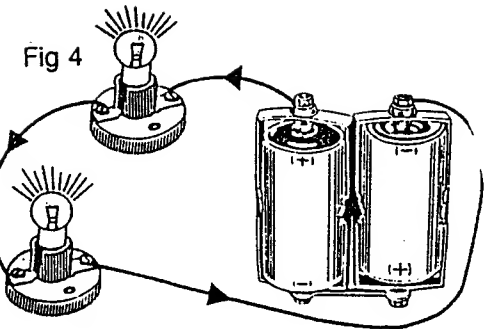
## EXPERIMENT 4

Parts : Bulbs—2, Bulb holders—2, Switch, Connecting wires, Battery (3 volts)

### The Series Circuit

Screw the bulb into the holders and connect them as shown in fig. 4. The two bulbs glow and they are said to be **connected in series**. The battery voltage divides itself into two, across each bulb. Observe that the glow on each bulb is less than in experiment 1.

Connect the switch in the circuit—fig. 4A. Both bulbs can be switched on or off at the same time. Here again, the current flows from the positive to the negative terminal of the battery through the bulb filaments and the switch.



## EXPERIMENT 5

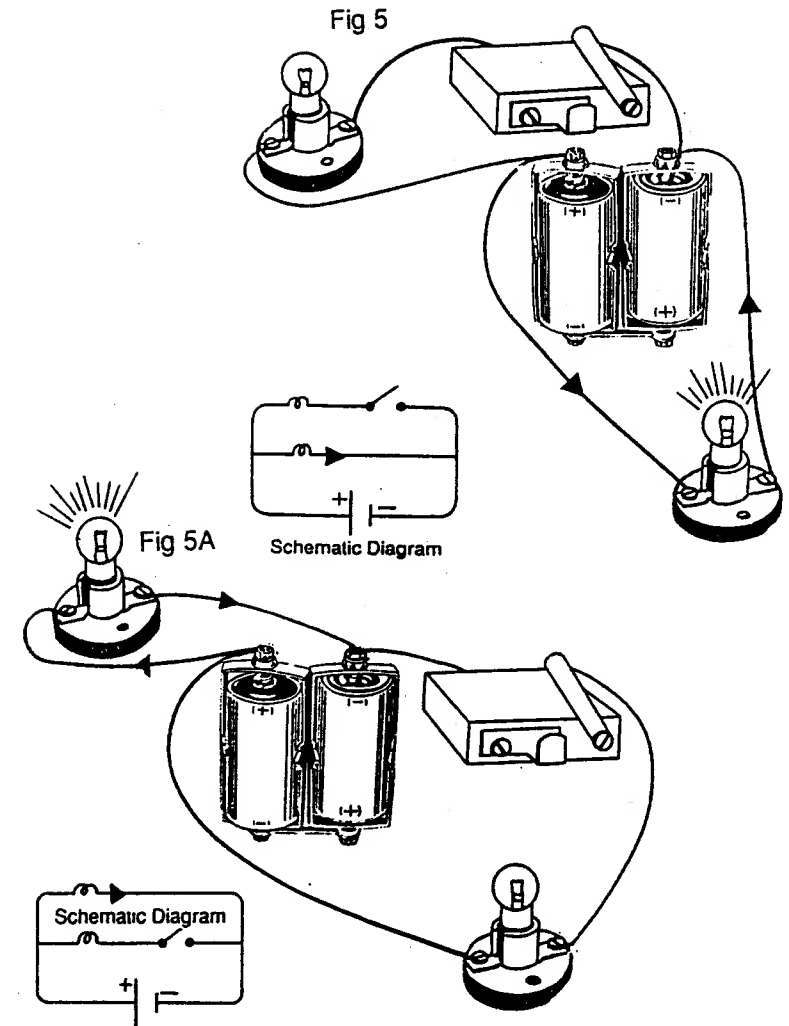
Parts : As in experiment 4.

### The Parallel Circuit

Connect the two bulbs as in figure 5. One of the bulbs is in series with the switch. This bulb can be switched on and off while the other glows continuously.

Replace the switch in series with the other bulb as in fig. 5A. This bulb can be controlled while the first glows.

Thus, if two switches are connected in the circuit, one in series with each bulb, any of the bulbs can be switched on or off as desired. This is how all the lamps at home are connected.



## EXPERIMENT 6

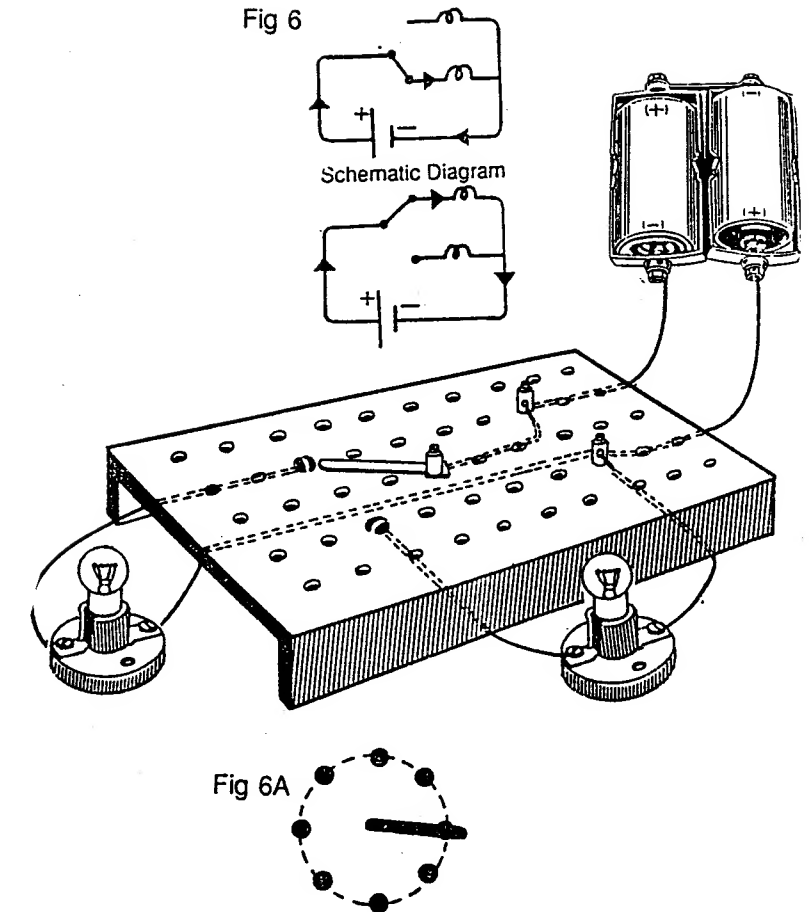
Parts : Baseboard, Moving Switch contact,  
Bulbs—2, Bulb holders—2,  
Terminals—3, Connecting wires,  
Battery (3 volts), Screw : f—2.

### The Two-way Switch

Fix the moving switch contact on the baseboard with the terminals as shown. Fix two screws f on the baseboard. Make connections to the bulbs and to the two terminals and connect the battery to these two terminals—fig. 6. Depress the moving contact on one screw head. One of the bulbs glows. Swing the switch contact to the other screw-head and depress it. The other bulb now glows.

The current from the battery can thus be diverted to the two different branches with two fixed contacts (screws f) and one moving contact.

In this way, it is possible to divert current through several branches, the fixed contacts and the moving contact being arranged as illustrated in fig. 6-A.



## EXPERIMENT 7

**Parts :** Bar Magnets—2, Iron filings, Short L rod, Moving switch contact.

## Permanent Magnets

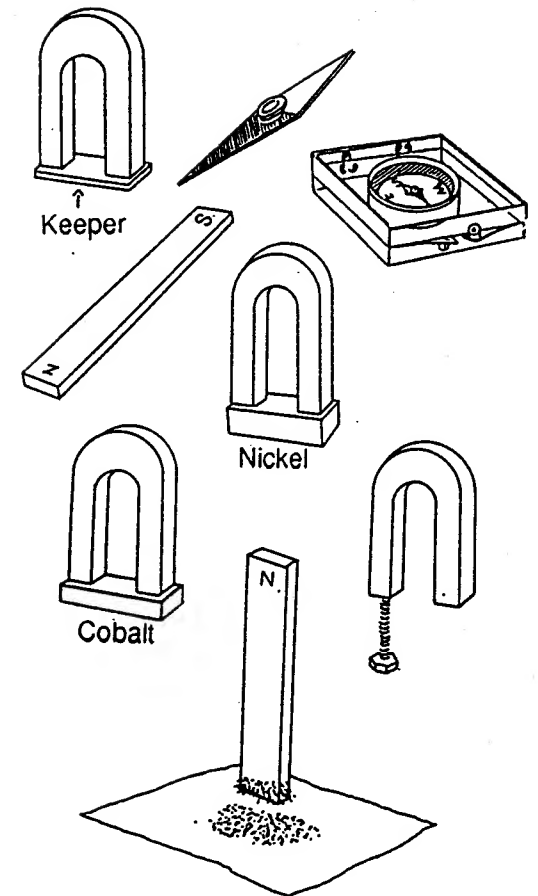
Permanent Magnets are made in various shapes (Bar, Needle, Horseshoe, etc.). Permanent magnets are so called because their magnetic properties are always present. Such magnets do not depend for their magnetism on the flow of electric current.

Permanent magnets have the property of attracting certain materials like Iron, Cobalt and Nickel. These substances are called Ferro-Magnetic substances. Any form of magnet has two poles at its ends, a North Pole and a South Pole. The North Pole is marked 'N' and the South Pole 'S'.

Bring the bar magnet close to iron filings sprinkled on a piece of paper. It attracts the filings—fig.7. Observe that the filings are attracted towards the ends of the magnet, showing that the magnetism is concentrated at the two ends or poles of the magnet. The magnet also attracts the L rod when brought near it.

Repeat the experiment with the moving switch contact. The magnet does not attract the contact as this is made of brass, which is not ferromagnetic.

**Fig 7**



## EXPERIMENT 8

Parts : Bar magnet, Iron filings.

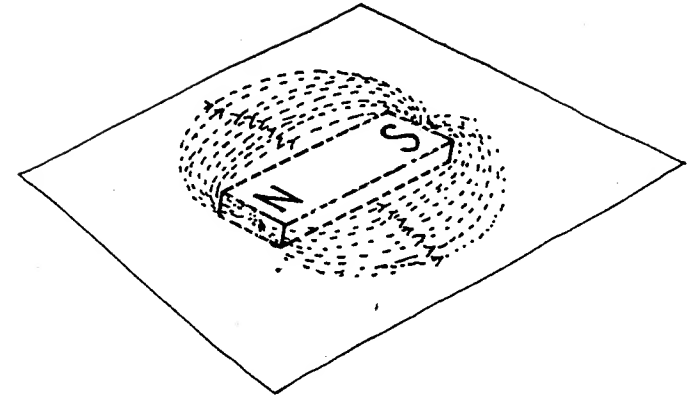
### Magnetic Lines of Force

Place a fairly thick sheet of white paper on the bar magnet. Sprinkle iron filings on the sheet, just above the magnet. Tap the paper lightly a number of times. The filings arrange themselves in a definite pattern along lines as shown in fig. 8.

The lines along which the filings arrange themselves are called **Magnetic Lines of Force**.

The direction of these lines of force is from the North to the South pole of the magnet. This applies to any form of Magnet.

Fig 8



## EXPERIMENT 9

Parts : Magnetic Compass

### The North-South Direction (The Magnetic Compass)

Place the compass on a level surface, away from iron parts. (fig. 9A) Observe the direction of the red end (North Pole) of compass needle. Turn the compass box on its base to another position (9B) when the needle comes to rest, it does so in the same direction, with the red end (North seeking pole) pointing North. This happens because the earth's magnetic field orients the compass needle in the north-south direction.

Turn the box gently on its base so that the red end of the compass needle is directly on "N" (9C) we can now identify the East, West, and South Directions, as also the North East (NE), North West (NW), South East (SE) and South West (SW) directions on the compass. The magnetic compass is a direction-finder.

Fig 9A

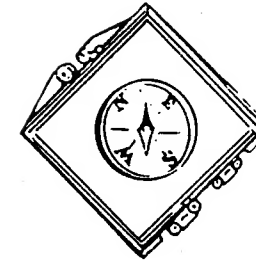
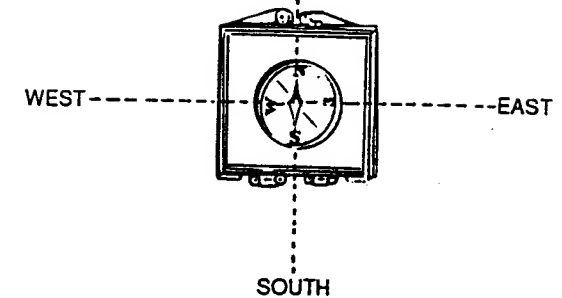


Fig 9B



Fig.9.C  
NORTH



## EXPERIMENT 10

Parts : Bar Magnet, Magnetic compass

### Tracking the lines of force

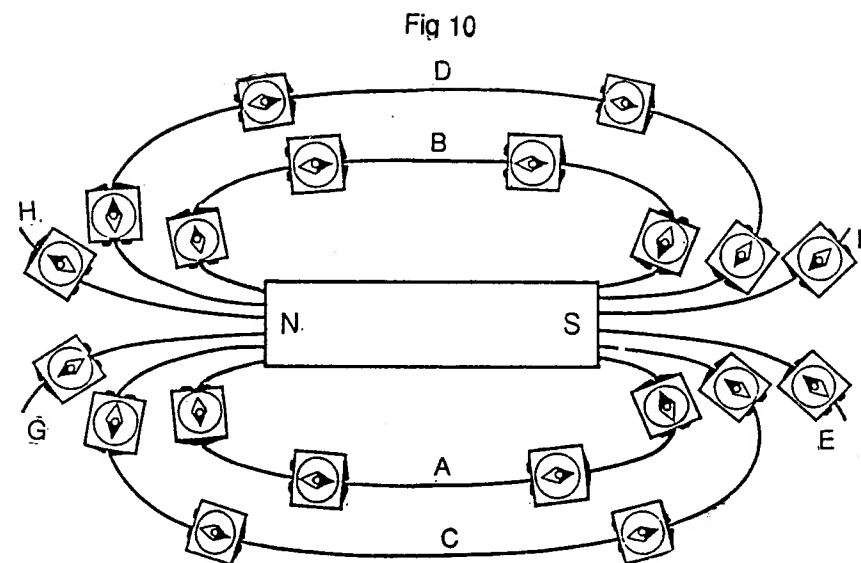
Place the bar magnet in the center of a sheet of white paper and trace its outline on the edge with a pencil. Keeping the compass horizontal on the paper, run the compass along the length of the bar magnet from the South pole to the North pole on either side of the magnet as shown by paths A, B, in the figure. Observe the position of the white tip of the compass needle along the path.

The white tip of the needle traces a line, from the South pole to the North pole of the bar magnet.

Each line traced by the needle tip represents a magnetic line of force. Repeat the experiment for different paths as shown in the figure (C, D, E, F, G, H).

The lines of force constitute a magnetic field.

In case the polarity of the compass needle is reversed follow the directions in Experiment 11





## EXPERIMENT 11

Parts : Bar magnet, Magnetic Compass.

### 'Like' poles repel

Place the compass on a level surface. The compass needle comes to rest in the N-S direction. Bring the North pole of the bar magnet (marked 'N') near the red end (N pole) of the compass needle, fig. 11. Observe that the red end of the needle is repelled by the North pole of the magnet.

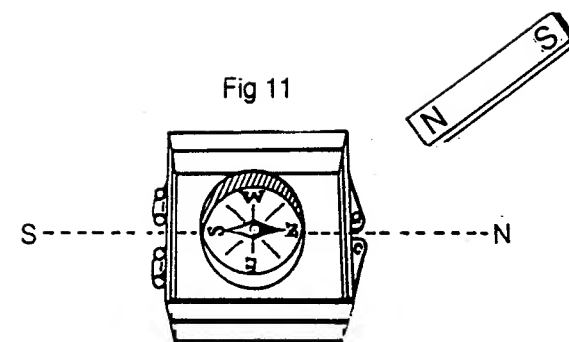
Bring the South pole of the bar magnet near the bright end of the needle. The bright end of the needle is the South pole of the needle. The bright end is repelled by the South pole of the magnet.

Therefore, 'Like' poles repel each other.

Note : In case of accidental reversal of compass polarity, follow these directions to rectify the compass magnet:

Bring the North pole of the bar magnet gradually towards the compass needle.

When the North Pole is directly above the approaching tip of the compass, move it rapidly along the length of the needle over to the other side. If done correctly the original polarity should be restored.



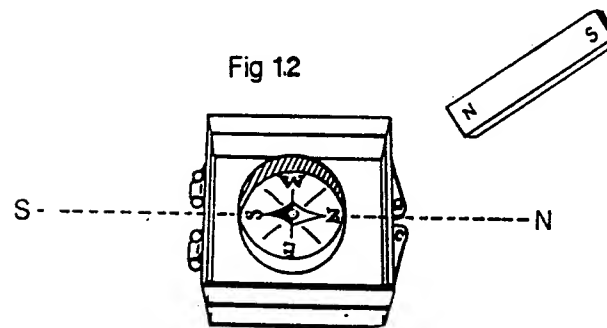
## EXPERIMENT 12

Parts : As in Experiment 11.

### 'Unlike' poles attract

With the compass needle at rest in the N-S direction, bring the North pole of the bar magnet near the bright end (S pole) of the needle. Observe that the bright end is attracted by the North pole of the magnet. In the same way, the red end (N pole) of the compass needle is attracted by the South pole of the bar magnet.

Therefore, 'Unlike' poles attract each other.



## EXPERIMENT 13

Parts : Solenoid, Switch, Magnetic Compass, Connecting wires, Battery (3 volts)

### The Solenoid

Magnetism caused by an electric current

The solenoid consists of a number of turns of enamelled copper wire wound on an insulating former. The solenoid depends for its magnetism on the flow of electric current. i.e., it behaves like a magnet when current flows through the coil and ceases to be so when the current is switched 'off'.

Connect the solenoid to the battery. Bring the coil near (about 1" ) the 'N' pole of the compass. The needle is attracted or repelled. This experiment indicates the presence of magnetism due to an electric current passing through the solenoid coil.

To prevent battery drain, do not connect battery to solenoid coil for more than a few seconds at a time.

## EXPERIMENT 14

Parts : Solenoid, Switch, Core, Iron Filings,  
Connecting wires, Battery (3 volts)

### Increasing the magnetic strength

Connect the solenoid to the battery. Bring the coil near the iron filings. Observe that no filings are attracted by the solenoid.

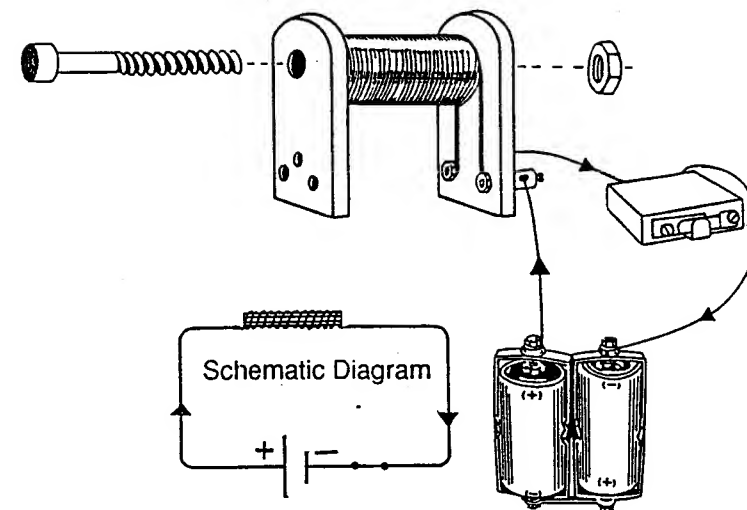
Now insert the core in the solenoid, fastening it with the nut —fig.14. With the switch in the circuit (ON), repeat the experiment. It is found that iron filings are attracted towards the core. Switch off. The filings fall from the electromagnet.

This shows that when a ferro-magnetic (steel) core is inserted in the solenoid the magnetic effect is increased. Such an arrangement is called an electromagnet.

Ideally, 'soft' iron is used for the core, because it acts as a magnet only when the current is 'ON'. Since a steel bolt is used here, it may retain some magnetism, even after the current is switched 'off'.

Repeat experiment 14 with the magnetic compass and observe increased attraction or repulsion of the compass needle compared with experiment 13.

Fig 14



## EXPERIMENT 15

Parts : Solenoid, Switch, Core, Iron filings, Connecting wires, Battery (3 volts).

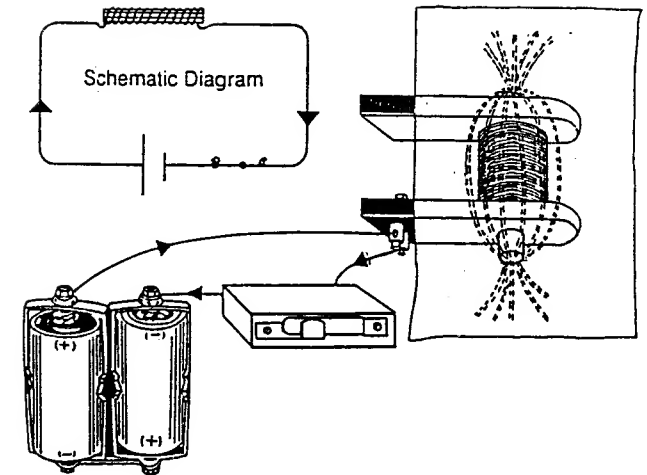
### Magnetic Lines of Force using an Electro-magnet

Insert the core into the coil and lock it in position with the nut. Connect the coil to the battery through the switch (OFF).

Place a sheet of white paper on the coil. Sprinkle iron filings uniformly on the sheet and tap the paper lightly. There is no definite arrangement of the filings.

Switch 'on' and tap the sheet lightly. The filings arrange themselves along curved lines – Fig. 15. These lines are the magnetic lines of force running from the North to the South pole of the magnet, similar to that of a permanent magnet (Experiment 8).

Fig 15



## EXPERIMENT 16

Parts : Solenoid, Core, Magnetic Compass, Switch, Connecting wires, Battery (3 volts).

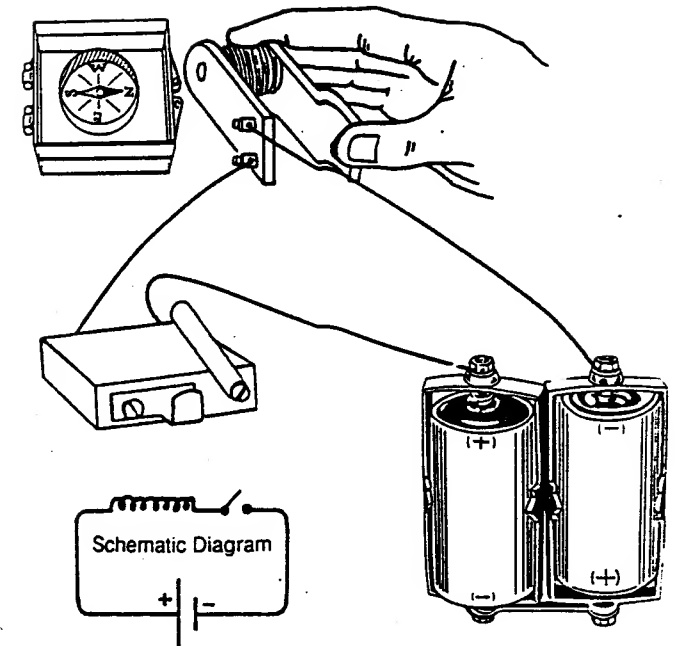
### The Poles of an Electromagnet

Place the compass on a level surface. The compass needle comes to rest in the N-S direction.

Connect the solenoid to the battery through the switch (OFF).

Bring the terminal end of the solenoid near the red end of the needle—fig. 16. Switch on. The needle is attracted or repelled. Switch off. The needle returns to the N-S direction. Now bring the other end of the coil close to the red end of the needle. Switch on. The opposite effect is observed. Switch off. The above experiment proves that the solenoid, when electrically energized, has two magnetic poles, one North and the other South. Repeat the experiment with the core inserted in the coil and observe that the effects are more pronounced.

Fig 16



## EXPERIMENT 17

Parts : Solenoid, Core, Magnetic Compass,  
Switch, Connecting wires, Battery (3  
volts) Screw 'e' --> 2

### Reversing the poles of an Electromagnet.

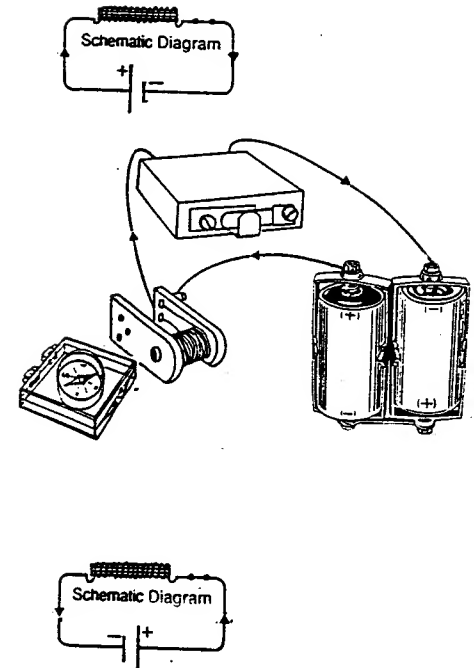
Insert the core into the solenoid and lock it with the nut. Place the compass on a level surface. The needle comes to rest in the N-S position. Turn the compass so that the red end of needle is on "N". Connect the electromagnet to the battery through the switch (OFF) and bring the core head near the red end of compass needle.

Switch on. Observe that the compass needle is attracted or repelled. Switch off. Reverse the connection to the battery. Switch on and observe the opposite effect on the compass.

This experiment illustrates how the poles of an electromagnet can be reversed by reversing the direction of current in the coil.

In the above experiment, can you determine the N and S poles of the electromagnet for a given connection of the electromagnet to the battery?

Fig 17



### EXPERIMENT 19

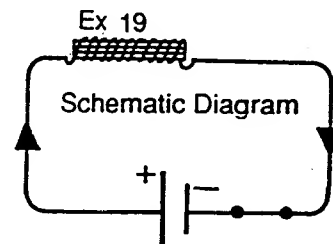
Parts : Reel, Enamelled wire, sand paper, Magnetic Compass, Switch, Iron filings, Battery (3 volts), Screw -->d.

**Increasing the magnetic strength of the solenoid.**

Insert screw d into the solenoid of Experiment 18, locking it in position—fig. 19.

Repeat the test for attraction with the filings and for attraction and repulsion with the magnetic compass. Increased magnetic effects are observed. By reversing the connections to the battery, the poles of the solenoid can be reversed, as in Experiment 17 on the electromagnet.

The solenoid, therefore, has properties similar to the solenoid provided in the kit.



### EXPERIMENT 20

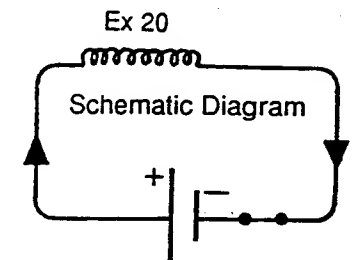
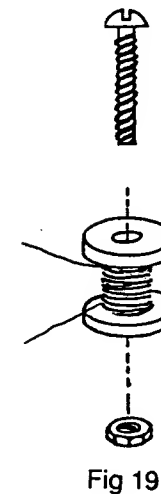
Parts : Reel, Enamelled wire, Magnetic Compass, Switch, Iron filings, Battery (3 volts)

**Increased magnetic strength with more turns of wire.**

Wind a solenoid of about 40 turns in the **same direction**. Scrape off the enamel of the wire ends thoroughly using sand paper.

Repeat the tests of Experiment 18. It is observed that the magnetic effect is increased.

Use battery sparingly.



## EXPERIMENT 21

Parts : Reels—2, Enamelled wire, Connecting wires, sand paper, Magnetic compass, Switch, Rotor rod, Battery (3 volts)

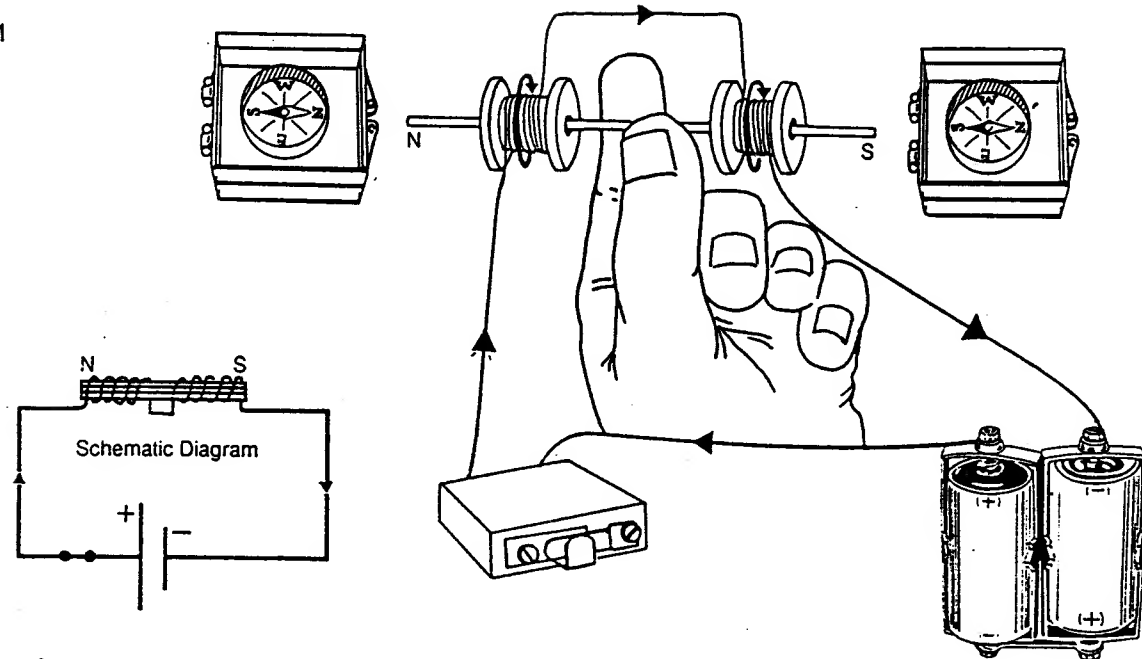
### Resultant Magnetic Field of two coils wound in the same direction

Insert the rotor rod through the two reels. Wind about 20 turns of the enamelled wire on each reel in the same direction, with about 3" of wire between the reels as indicated. Scrape off the

enamel at the ends of the wire thoroughly with sand paper. Connect these ends to the battery, with the switch in the circuit—fig.21.

Bring the magnetic compass near one end of the rod. Switch on. Observe the end of the needle that is attracted to the rod. Now bring the magnetic compass near the other end of the rod. The opposite end is attracted because the rod is magnetized in the same direction throughout its length, with poles as shown. Switch off.

Fig 21





## EXPERIMENT 22

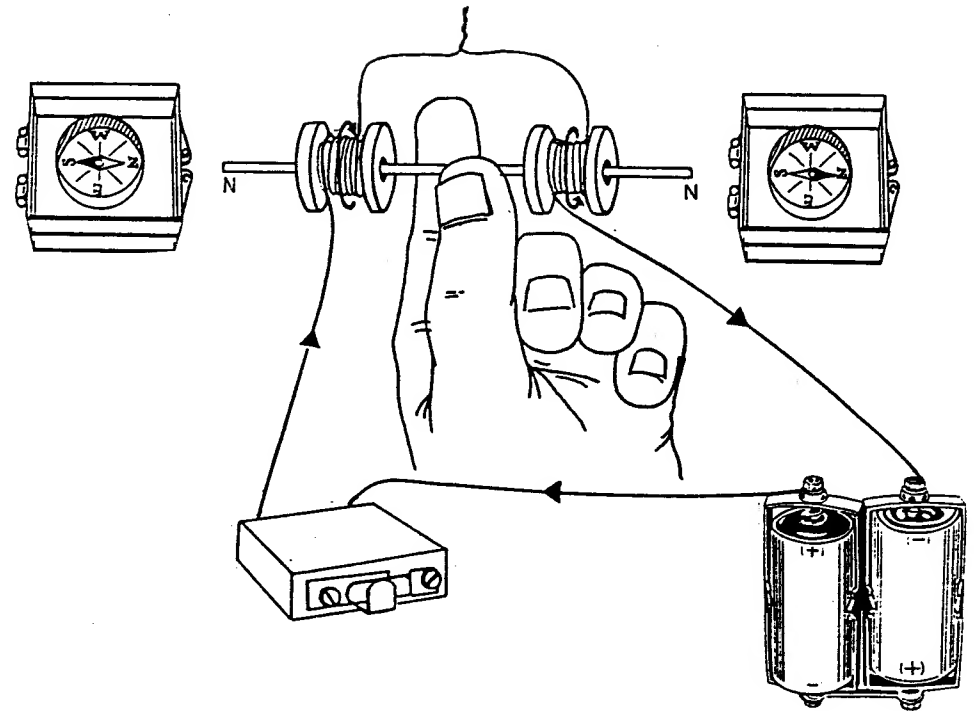
Parts : As in Experiment 21.

### Resultant Magnetic Field of two coils wound in opposite directions

With the same arrangement as in Experiment 21, at the length of wire between the two reels and make connections as shown, removing the insulation thoroughly at the points of connection - fig. 22.

Repeat the tests of Experiment 21. The same end of the compass needle is attracted by both ends of the rod.

This shows that the rod is magnetized in opposite directions along its length.



### EXPERIMENT 23

Parts : Bar magnet, Rotor rod, Iron filings, Magnetic Compass.

#### Magnetizing with a Permanent Magnet

In this experiment, the bar magnet is used to magnetize the rotor rod.

To magnetize the rod, bring the S pole of the bar magnet near the threaded end of the rod and stroke the rod along its length with this pole a number of times in the manner shown in fig. 23.

When the rod is tested for magnetism, it is found to behave like a bar magnet with the S pole at the threaded end and the N pole at the other end. To magnetize the rod in the opposite direction, it is stroked in the same manner, but this time with the N pole of the bar magnet.

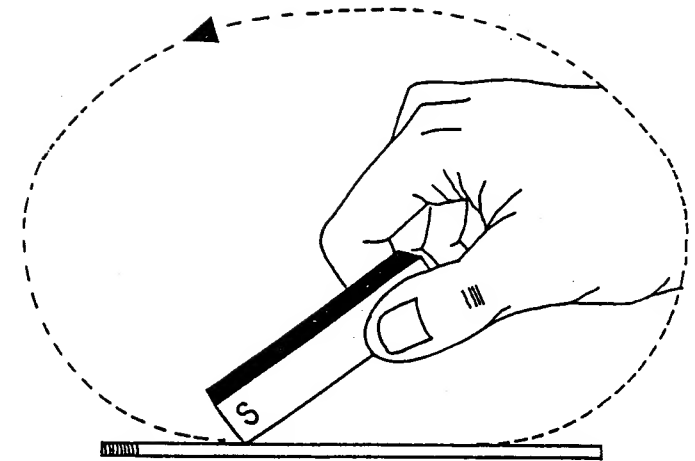


Fig 23

## EXPERIMENT 24

Parts : Solenoid, Long L rod, Magnetic Compass, Sand paper, Iron filings, Switch, Enamelled wire, Battery (3 volts), Connecting wires.

### Magnetizing with an Electric Current

Insert the L rod into the Solenoid and connect the solenoid to the battery through the switch (OFF) per fig.24. Switch on the current for about 20 seconds. Switch off.

Remove the rod and test it for magnetism. The rod attracts the iron filings. Also, the same end of the rod repels one pole of the compass needle and attracts the other. The rod is therefore magnetized.

Remove enamel from wire at points of connection, using sand paper.

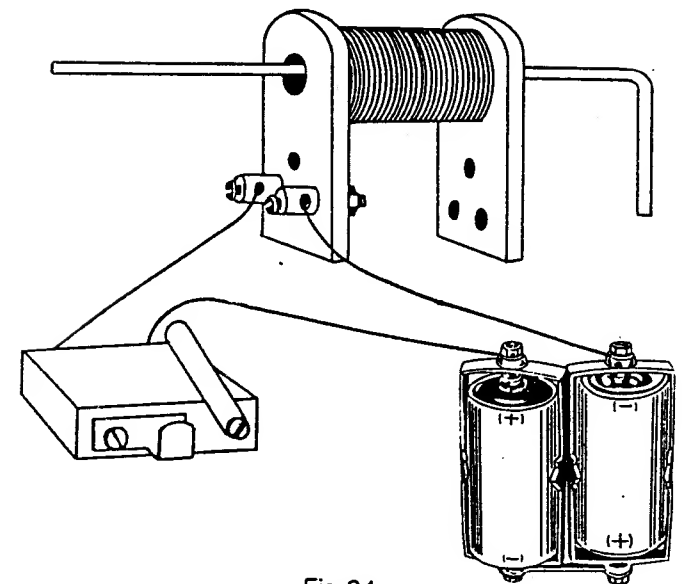
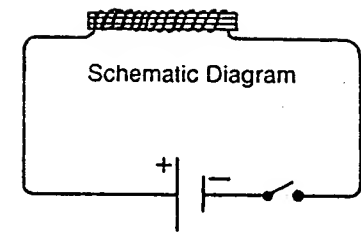


Fig 24

### EXPERIMENT 25

Parts : Rotor rod, Magnetic Compass, Bar magnet.

#### Direction Finder

Magnetize the rotor rod using the method of Experiment 24.

Suspend the magnetized rotor rod using the string as in fig. 25. The rod comes to rest in the N-S direction after a number of to and fro movements.

Verify the direction as N-S by comparison with the direction indicated by the magnetic compass.

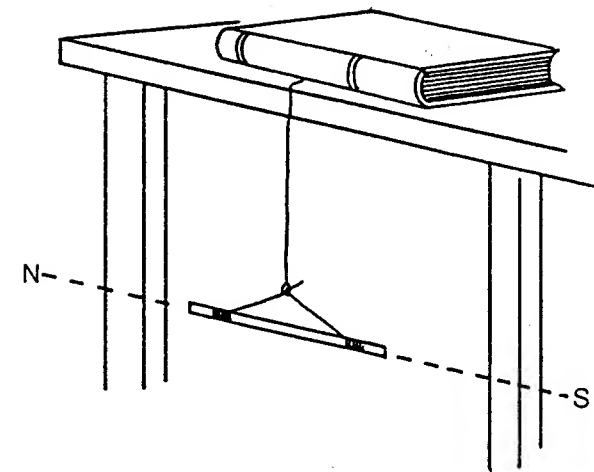


Fig 25

### EXPERIMENT 26

Parts : Long L rod, Magnetic Compass, Iron filings.

#### Demagnetizing

Drop the magnetized L rod on the ground a number of times. Test the rod for magnetism, i.e. for attraction with the iron filings and for attraction and repulsion with the magnetic compass. You will observe that there is a decrease in magnetism, if not complete demagnetization.

It is therefore important that magnets not be dropped if they are to retain their magnetism.

## EXPERIMENT 27

Parts : Solenoid, Long L rod, U bracket,  
Fastening strip (white), Baseboard,  
Switch, Small sleeve— $\frac{1}{16}$ ",  
Terminals—2, Enamelled wire,  
Connecting wire, Battery (3 volts)  
Screws : e—2, f—2.

### Solenoid action.

Assemble the solenoid on the baseboard with fastening strip and screws e. Fix the U bracket to the base with screw f. Insert the L rod through the bracket holes with the sleeve on the L rod as indicated. Fix the switch to the baseboard. Ensure free movement of the L rod in the U bracket by centering the solenoid bore with respect to it. Make connections as shown in fig. 27, through the switch (OFF). Adjust the sleeve for the position of the L rod (slightly inside the solenoid) indicated in fig. 27.

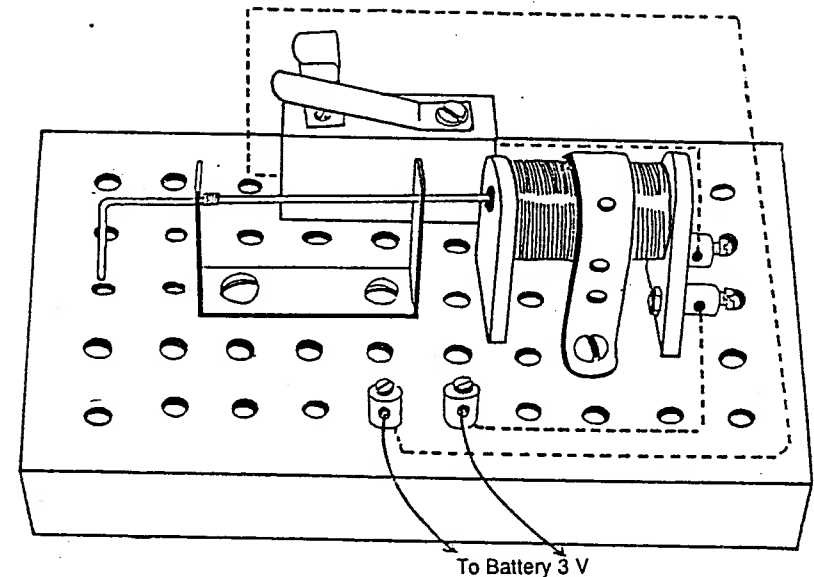
Switch on. The rod is pulled into the solenoid.  
Switch off. The above action of the solenoid is used in relays to 'make' or 'break' an electrical circuit.

**Dotted lines indicate enamelled wire**

**Bold lines indicate connecting wire**

**Remove enamel at points of connection**

Fig 27



## EXPERIMENT 28

Parts : Magnetic compass, Switch, Connecting wires, Battery (1.5 volts)

### Magnetic effect of an electric current

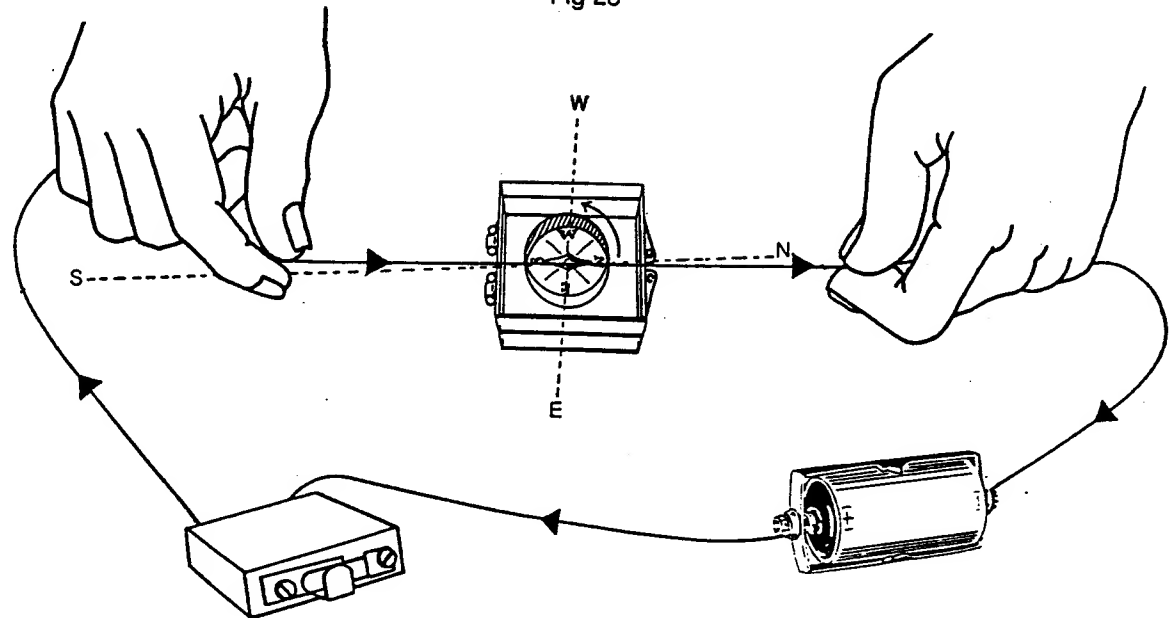
Place the Compass on a level surface. The compass needle comes to rest in the N-S position after a few swings.

With the connection shown and the switch ON, stretch the connecting wire in the N-S direction

along the length of the needle—fig.28. The red (N) end of the needle is observed to deflect to the West when the current is flowing from South to North in the straight portion of the wire. Reverse the battery connection. The red end now deflects East. Switch off.

Remove enamel at points of connection.

Fig 28



## EXPERIMENT 29

Parts : Compass, Enamelled wire, Switch, Connecting wires, Battery (1.5 volts), Sand Paper.

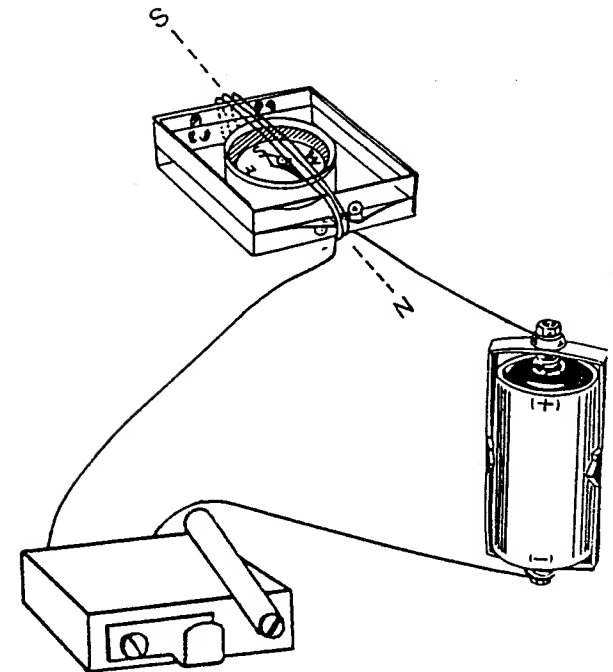
### Measuring Instruments The Galvanometer

Wind 7 turns of enamelled wire around the compass box, running the wire between the tab spaces of the compass box sides. Scrape off the insulation at the ends of the wire thoroughly using the sand paper.

Place the compass box on a level surface and turn the box such that the North Pole (red end) of the compass needle is at "N", in its position of rest. Make the connections shown in fig. 29, using the battery, with the switch "OFF". Now switch the current "ON". The compass needle turns in a particular direction, and tends to align itself with the coil axis. Switch "OFF". The compass needle returns to its original position.

The deflection of the needle from its original position is a measure of the current flowing through the instrument (galvanometer).

Fig 29



### **EXPERIMENT 30**

Parts : Galvanometer, Switch, Connecting wire, Battery.

#### **Reversing the current in the Galvanometer**

Repeat Experiment 29. Switch off. The needle comes to rest in the N-S position. Reverse the battery connection. Switch on. The compass needle is again deflected, but now in the opposite direction.

This happens because the magnetic poles of the coil are reversed owing to the reversal of current in the coil. Switch off. The needle returns to its original position.

In experiments 29 and 30, can you trace the current flow direction in the coil winding (around compass box) and relate it to the compass deflection? (See experiment 18 for similarities)



### EXPERIMENT 31

Parts : As in Experiment 30.

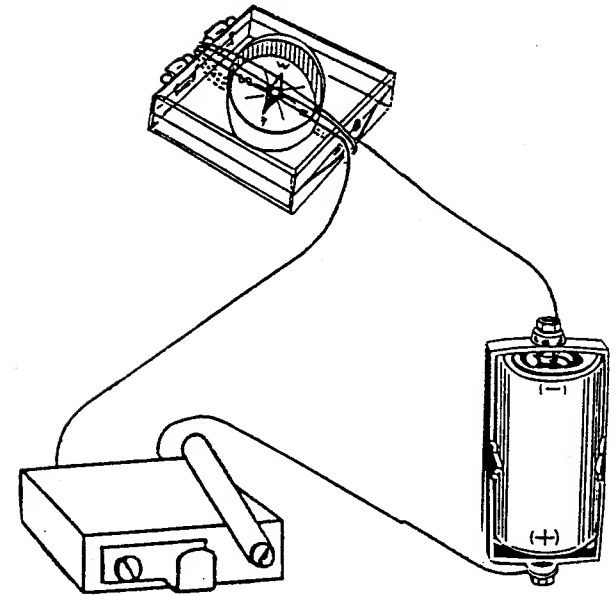
#### A greater deflection in the galvanometer

With the same assembly as in Experiment 29, and the switch OFF, turn the compass box so that the N pole of the compass needle is above the "E" or "W" mark.

Switch on. The needle is now found either to deflect through a half revolution or not at all. If it does not deflect at all, switch off. Reverse the battery connection and switch on. The maximum deflection is observed. Switch off.

Can you explain why this happens ?

Fig 31



### EXPERIMENT 32

Parts : Galvanometer, Bulbs—2, Bulb holders—2, Switch, Connecting wires, Battery (3 volts).

#### Resistances in series with the galvanometer

Repeat Experiment 29 with 3V battery supply. Observe the deflection of the needle from its original position. Replace the switch by the bulb holder as shown in fig. 32. Screw in the bulb and observe the deflection. The bulb glows and the deflection is found to be less than before. Screw out the bulb. The bulb goes off. The compass needle returns to the N-S position. The deflection is less because the resistance of the bulb filament lowers the current through the galvanometer. Introduce another bulb in the circuit as in fig. 32A, so that the two bulbs are in series with the galvanometer. With the bulbs screwed in, the deflection is observed to be reduced further. Each bulb glows less than before. By screwing out any of the bulbs, the current can be switched off. The deflection is reduced because of the additional resistance of the second bulb in the circuit which lowers the current further. In the above experiment, the bulb can be used to switch 'on' or to switch 'off' the current, by screwing it into, or out of its holder.

Refer to Experiment 4, for similarities. When resistances are connected in series the current in the circuit decreases.

Fig 32

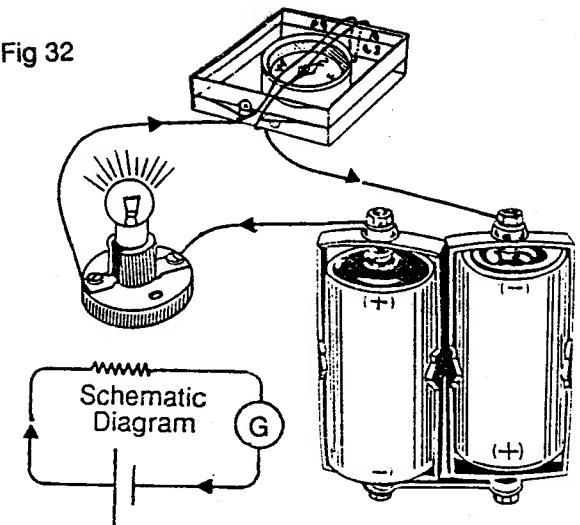
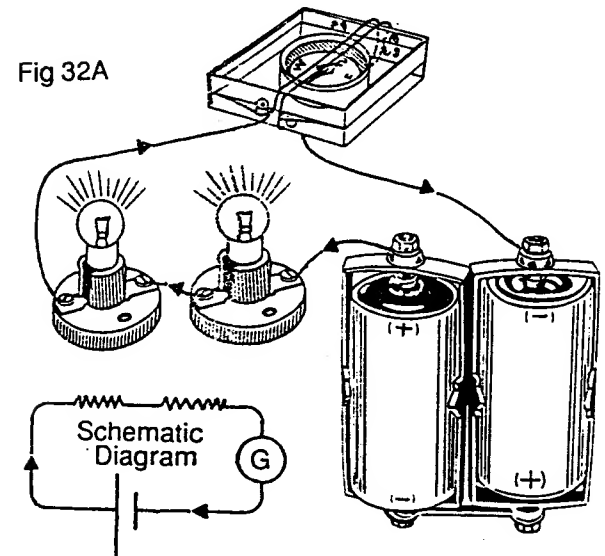


Fig 32A



### EXPERIMENT 33

Parts : As in Experiment 32.

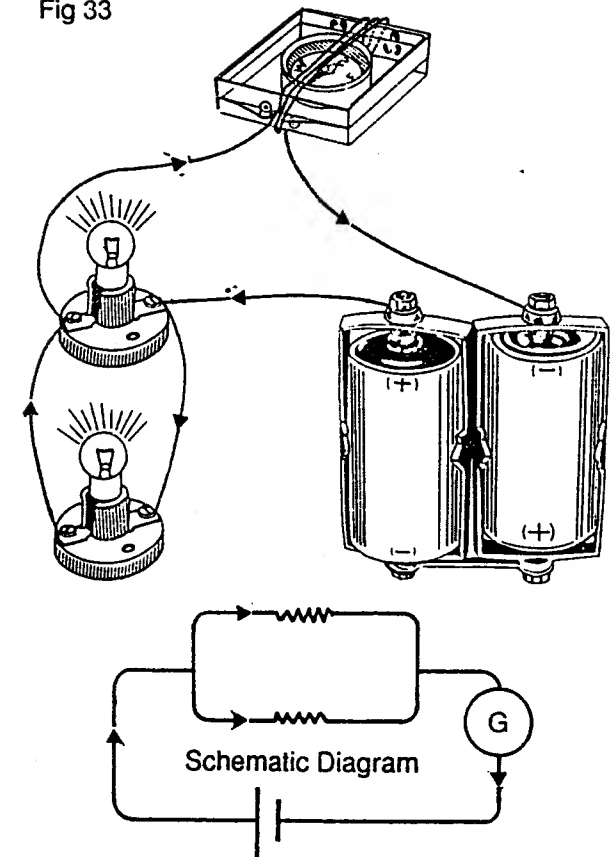
#### Resistance. in parallel in the galvanometer circuit

Connect the bulbs in the galvanometer circuit as in fig. 33, with both the bulbs screwed out. There is no deflection because there is no current through the galvanometer.

Screw in one bulb and observe the deflection. Now screw in the other bulb. The deflection is increased. This shows that there is an increase of current in the circuit.

The bulbs are now connected in parallel. Since there are 2 paths through which the current can flow, the current in the circuit increases. The effective resistance of the circuit decreases, and is less than that of one bulb. Screw out the bulbs.

Fig 33



## EXPERIMENT 34

Parts : Solenoid, Long L rod, Rotor rod, U bracket, Baseboard, Switch, Fastening strips—2, Meter scale\*, Small sleeves 1/8"—4, Terminals—3, Enamelled wire, Sand Paper, Connecting wires, battery (4.5 volts).  
Screw : e—2. f—4.

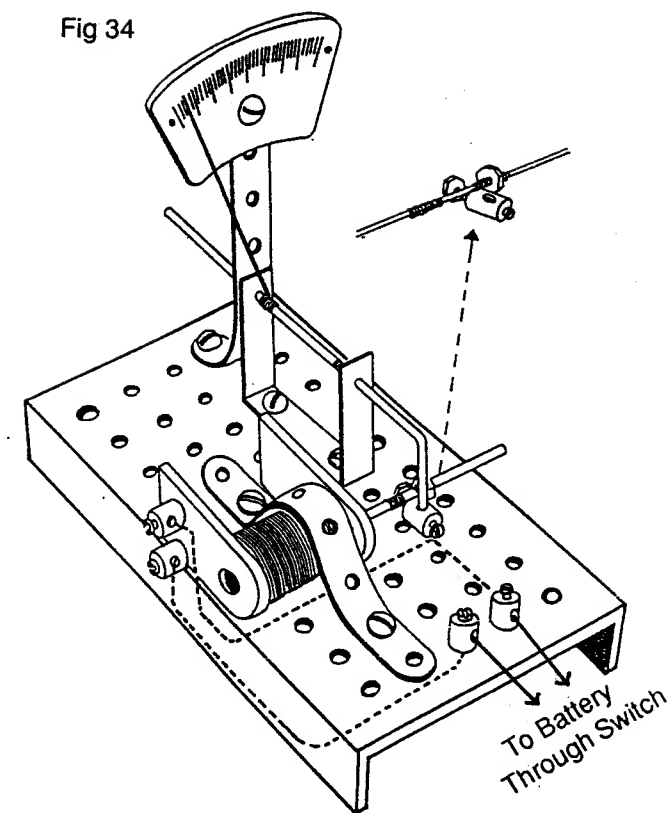
### The Moving Iron Meter (Attraction type)

Fix the solenoid to the baseboard with the white fastening strip and screws e. Fix the U bracket to the baseboard with screws f. Insert the L rod through the bracket holes, with the sleeves as shown, one sleeve supporting about 3" length of enamelled wire to serve as the pointer. Fix the meter scale to the coloured fastening strip with screw f. Fasten this arrangement to the baseboard with screw f. Adjust this screw so that the L rod moves freely in the hole of the strip as in fig. 34.

The moving iron assembly consists of the rotor rod with sleeves and nut, placed on the terminal fixed to the L rod — fig. 34. Adjust the height of this terminal so that the rod moves freely in the solenoid. With the L rod at rest, adjust the pointer, so that it is along the extreme left division of the scale. The connections are as shown, with the switch (OFF) in the circuit—fig. 34.

\* Cut out from back page of Manual

Fig 34



### **EXPERIMENT 34 (Contd.)**

Switch on. The pointer moves across the scale. Adjust the position of the solenoid for good deflection. Switch off. The pointer returns to its original position because of the weight of the moving system, the control being gravity. The deflection of the pointer from zero is a measure of the voltage. If the instrument is calibrated, the voltage of any source may be read directly on the scale.

With a 4.5 volt supply, the maximum deflection of the pointer is marked as 4.5 volts. With one flashlight battery, (1.5 volts) across the instrument, the deflection is less and may be marked on the scale as 1.5 volts. Similarly, the instrument can be calibrated for various voltages. The scale provided is uniformly graduated, though, in such instruments the scale is not uniform.

**Dotted lines indicate enamelled wire**

**Remove enamel thoroughly with sand paper at points of connection**

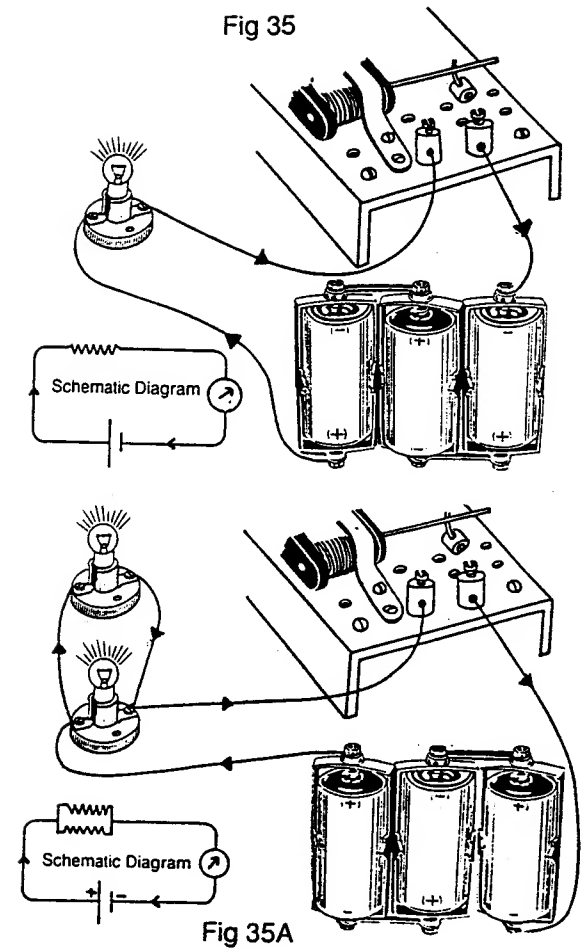
**Note: This assembly is used in Experiment 35.  
Do not dismantle !**

## EXPERIMENT 35

Parts : The Moving Iron Meter (Assy. of Exp. 34) Bulbs—2, Bulb holders—2, Connecting wires, Battery (4.5 volts)

### Reversing the current in the meter

Repeat Experiment 34 and observe the deflection of the pointer across the scale with 4.5 Volts. Switch off. The pointer returns to its original position. Reverse the connection to the battery and repeat the Experiment. The deflection is the same as before. This means that the operation of the meter does not depend on the direction of current flow. Switch off. As an additional experiment, replace the switch by the bulb holder (fig. 35). Screw in the bulb. The bulb glows. The deflection is less than before. Screw out the bulb. The pointer returns to zero. Connect another bulb holder in parallel with the first. Screw in both the bulbs—fig.35A The deflection is now greater than with one bulb. The reason for the above is outlined in Experiment 33. Screw out the bulbs.



### EXPERIMENT 36

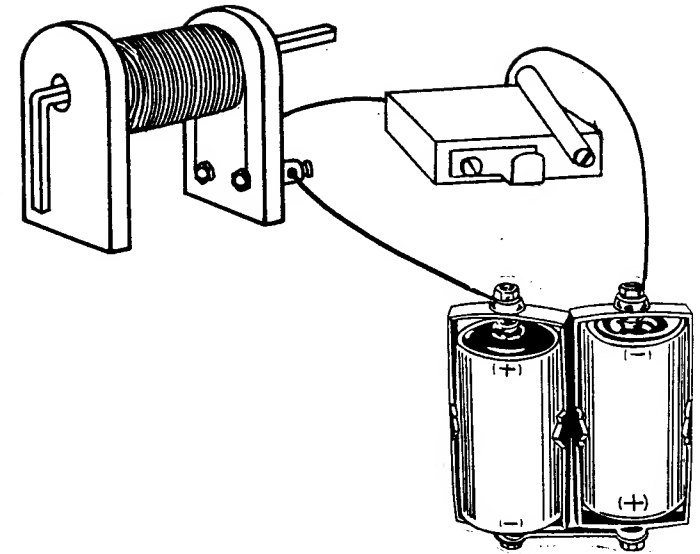
Parts : Solenoid, Short L rod, Long L rod, Switch, Connecting wires, Battery (3 volts)

#### The Principle of Repulsion

Insert the two L rods with the longer arms inside the coil. Connect the solenoid to the battery through the switch (OFF) — fig. 36.

Switch on. The two rods move apart. This happens because the two rods are magnetized in the same direction by the flow of current in the coil, i.e. the North poles of the rods are formed at one end of the coil and the South poles at the other end. Since 'like' poles repel, the two ends move part.

Fig 36



### EXPERIMENT 37

Parts : Quiz board (Index card), Paper clips  
-12, Enamelled wires-6, Sand paper  
(all these are under the baseboard)  
Bulb, Bulb Holder, Connecting wires,  
Battery (3 volts)

#### The Electric Quiz

Scrape off the brown insulation covering from the wire ends for a length of about 1" on each side, using the sand paper (for all six wires)

**Caution: Do not put sand paper in mouth. Do not rub your hands or any part of your body with the sand paper.**

**Caution :** \* When operating the quiz, do not connect battery each time for more than a few seconds.

\* Do not drop the bulb.

#### Quiz Board preparation

Choose any quiz topic. Let us choose state and state capitals of America. We shall plan for 6 questions and answers, and therefore we need to choose 6 states and their capitals. These are given below:

State	Capital
California	Sacramento
Colorado	Denver
New York	Albany
Arizona	Phoenix
Utah	Salt Lake City
Nebraska	Lincoln

On the left side of the card, list the states in the above order, as shown in fig. 37. Leave about 3/4" gap between the states as shown. On the right side, however, enter the capitals, not correctly against each state, but in scrambled form, as shown.

Attach the paper clips at the ends as shown, below each of the states and capitals. (The smaller loops of the clips on front). Loop the scraped end of one wire at the back of the "California" clip. Loop the other scraped end of the wire to the "Sacramento" clip, at the back of the card, similar to the above. Make the other 5 connections between the states and their capitals with the remaining wires, in similar fashion.



### EXPERIMENT 37 (Contd.)

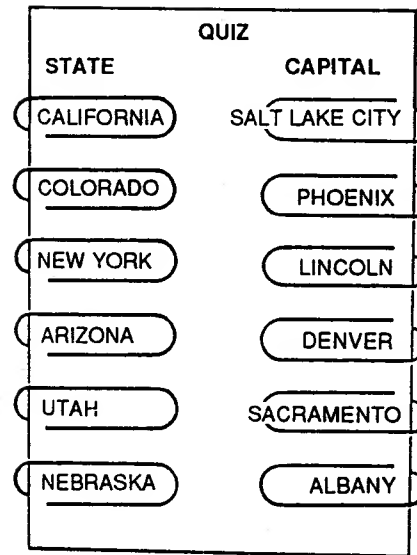


fig. 37

#### Caution :

- \* When operating the quiz, do not connect battery each time for more than a few seconds.
- \* Do not drop the bulb.

Long side of Quiz board.  
Wire connections between the states and their capitals are made under the quiz board, ensuring that the bare copper ends of wires make connections with the appropriate clips. Paper clip attached like this against names

How does the above Quiz Work?

Using the same Quiz Board, make another set of questions and answers, on any other topic.

#### Quiz Operation :

Connect the bulb to the battery as shown in fig 37A. We now have two wire ends, the bulb wire end and the battery wire end. Touch one free end to the "California" clip and the other to the "Sacramento" clip. If the connection is made properly, the bulb should glow. Test the other connections and check if the bulb glows for the correct answers.

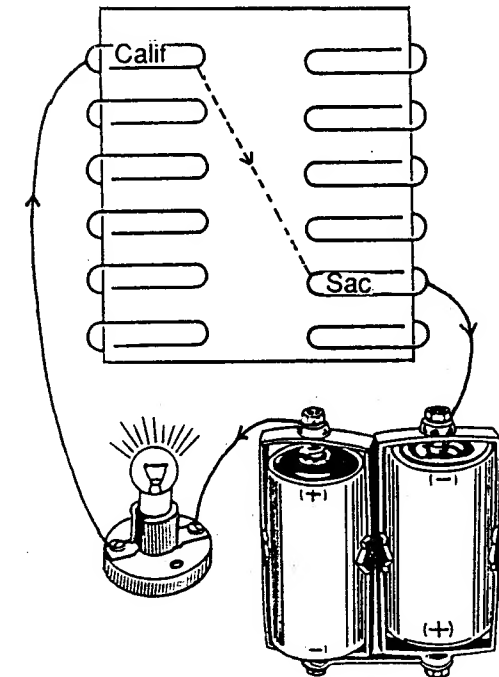


Fig 37 A

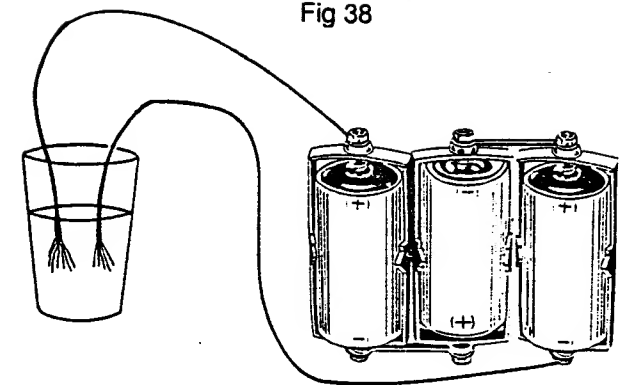
### EXPERIMENT 38

Parts : Connecting wires, Battery (4.5 volts)

#### The Conductivity of water

Make connections as shown in Fig 38.

Dip the two ends of wire in a glass of water. A thin 'smoke' of bubbles (or no bubbles) will be seen to rise from one of the wires dipping in the water. This shows that water has low conductivity as there is little or no electrochemical activity at one of the wires in the solution.



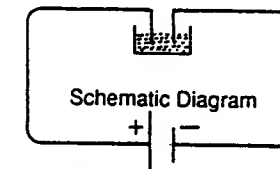
### EXPERIMENT 39

Parts : As in experiment 38

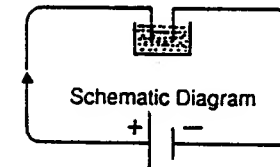
#### Increasing the conductivity of water.

With the same arrangement as in Experiment 38 add some common salt to the water and stir the solution. A thick 'smoke' of bubbles will be seen to rise from one of the wires dipping in the water. This shows that the conductivity increases by adding salt to the water. This is illustrated by increased electrochemical activity at one of the wires in the solution.

Ex 38:



Ex 39



## EXPERIMENT 40

Parts: Connecting wire, Battery (4.5 volts)

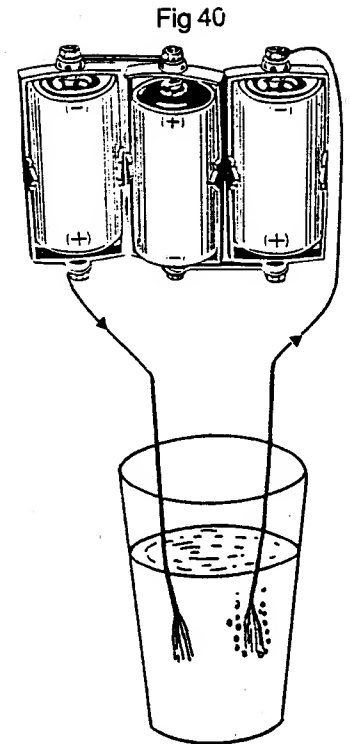
To find the positive and negative terminals of the battery, using Electrolysis.

Dip the two wires from the battery in a glass of salt water—fig.40. You will see bubbles form at the negative terminal of the battery and practically no bubble formation at the positive end. This is due to the phenomenon of Electrolysis, i.e., the splitting of the salt solution (electrolyte) into positive (+) and negative (-) ions, when current is passed through the solution. The positive hydrogen ions are attracted to the negative lead and form bubbles of hydrogen there, which tend to rise to the surface.

Thus it is possible to identify the negative terminal of a battery by looking for these bubbles.

These bubbles appear only when the current is flowing through the solution (Ref. Exp. 39). When you disconnect the battery terminals, the bubbles stop forming.

**Caution:** Do not bring any lighted match or flame nearer the glass, since hydrogen can ignite and cause fire and injury.



### EXPERIMENT 41

Parts: Potassium iodide crystals, Bell Gong,  
Connecting wires, Battery (4.5 volts)  
(contact wire-under baseboard) Screw—f

#### Write with electricity

Make a solution of the potassium iodide in about a quarter glass of water. Dip a piece of white paper in the solution. Spread out the paper on the gong surface.

Connect the arrangement as shown in fig. 41. It is possible to write on the paper with the tip of the contact wire. The battery current electrolyses the solution and the iodine formed leaves a brown impression on the paper at the points of contact.

If the battery is disconnected, there is no impression on the paper while writing, because there is no electrolysis, and there is no current passing through the solution. (Use the same solution for Experiment 42).

### EXPERIMENT 42

Parts: Potassium iodide solution (prepared in Experiment 41), Connecting wires, Battery (4.5 volts)

#### Electrolysis

Dip the two wire ends from the battery terminals in the potassium iodide solution. The solution is observed to turn yellow gradually. The yellow colour

illustrates the formation of iodine because of electrolysis of the solution. Remove the leads from the solution.

**Caution :** Do not swallow Potassium Iodide crystals or inhale near the solution. Do not bring the crystals to any part of your face or body. Wash hands thoroughly after handling potassium iodide solution.

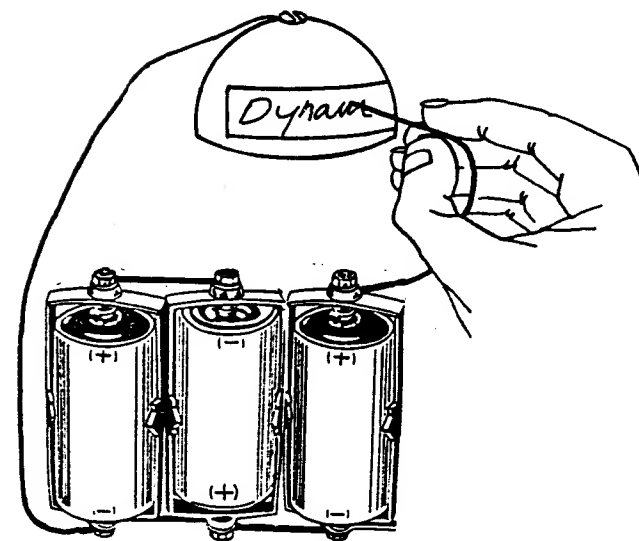


Fig 41

The following three experiments illustrate the basic concepts of switching circuits used in digital electronics and computers. Though switching is accomplished electrically in these experiments, electronic switching using semiconductor devices is used in digital circuits. These devices are called 'gates'.

Three basic operations called 'AND', 'OR', and 'NOT' are illustrated in these experiments.

Essentially, the 'NOT' circuit in electronics does not 'short-circuit' the source, since a 'gate' (microchip) performs this function.

However, the basic concept of 'negation' is conveyed through this experiment.

### EXPERIMENT 43

Parts : Baseboard, Bulb, Bulb Holder, Moving Switch Contact—2, Terminals—4, Enamelled wire, Connecting wire, Battery(3v) Screws : f—2.

#### The Logical 'AND' Circuit

Refer to fig. 43

Screw the bulb into the bulb holder. Fix the screws f onto the baseboard in the positions shown. Insert the terminals into the holes in the moving switch contacts. Fix the assemblies to the baseboard as shown in the figure so that the arms of the moving switch contacts are directly above the respective screws. Ensure that the moving switch contact does not make contact with the screws underneath. If they do, bend the arms upwards till the contacts are normally open.

Make connections per fig. 43. The bulb and switches are connected in series with the battery (Refer schematic Diagram)

Follow these steps :

- i. Leave switches A & B open. The bulb does not glow.
- ii. Press switch A alone. The bulb does not glow.

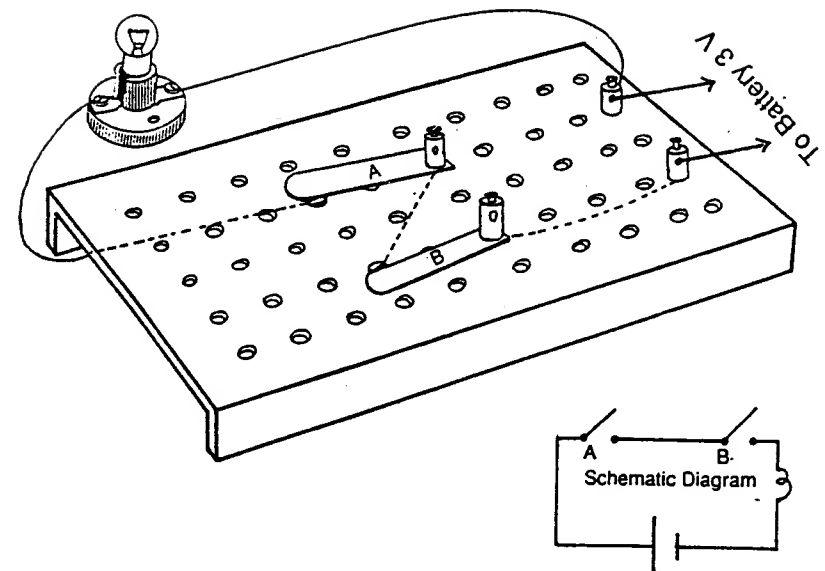


Fig 43

- iii. Press switch B alone. The bulb does not glow.
- iv. Press switches A & B together. The bulb glows.

Thus there are four possibilities.

- i. Switch A not pressed (Open), switch B not pressed (Open)
- ii. Switch A pressed (closed), switch B not pressed (Open)
- iii. Switch A not pressed (Open), switch B pressed (closed)
- iv. Switch A pressed (closed), switch B pressed closed.

The four possibilities are summarized with the result in a 'Truth Table' shown below:

Switch A	Switch B	Bulb
Open (O)	Open (O)	No Glow (O)
Closed (I)	Open (O)	No Glow (O)
Open (O)	Closed (1)	No Glow (O)
Closed (1)	Closed (1)	Glow (1)

The circuit is called a Logical 'AND' circuit. Switch open is represented by 'O' in the table and switch closed by '1'. The bulb not glowing is shown by a '0' while the bulb glowing is shown by a '1'.

With the above circuit the following statement is true.

"If switch A AND Switch B are closed the bulb glows."

## EXPERIMENT 44

Parts : Same as Experiment 43

### The Logical 'OR' Circuit

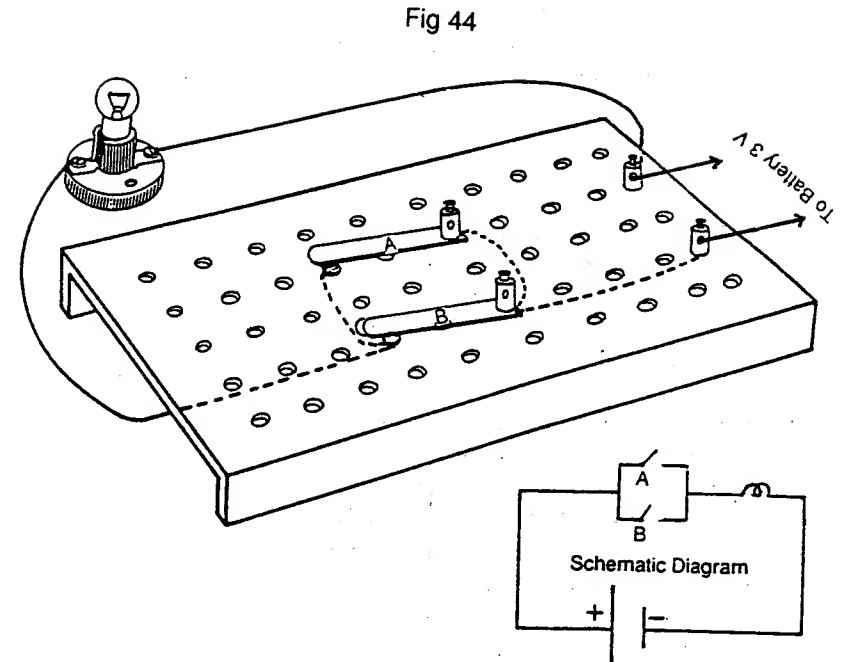
Refer to fig 44.

Remove the connections from the previous experiment and reconnect the switch, bulb and battery per fig. 44. Thus the switches are in parallel and the combination is in series with bulb and battery (Refer schematic diagram).

Follow these steps :

- Leave both switches A & B open. The bulb does not glow.
- Press Switch A alone. The bulb glows.
- Press Switch B alone. The bulb glows.
- Press both switches A & B. The bulb glows.

The truth table for these 4 possibilities is summarized below:





Switch A	Switch B	Bulb
Open (O)	Open (O)	No Glow (O)
Closed (I)	Open (O)	Glow (1)
Open (O)	Closed (1)	Glow (1)
Closed (1)	Closed (1)	Glow (1)

Compare this with the truth table of the previous experiment.

The above circuit constitutes a logical 'OR' circuit.

The following statement is true:-  
If Switch A OR Switch B is closed, the bulb glows.

#### EXPERIMENT 45

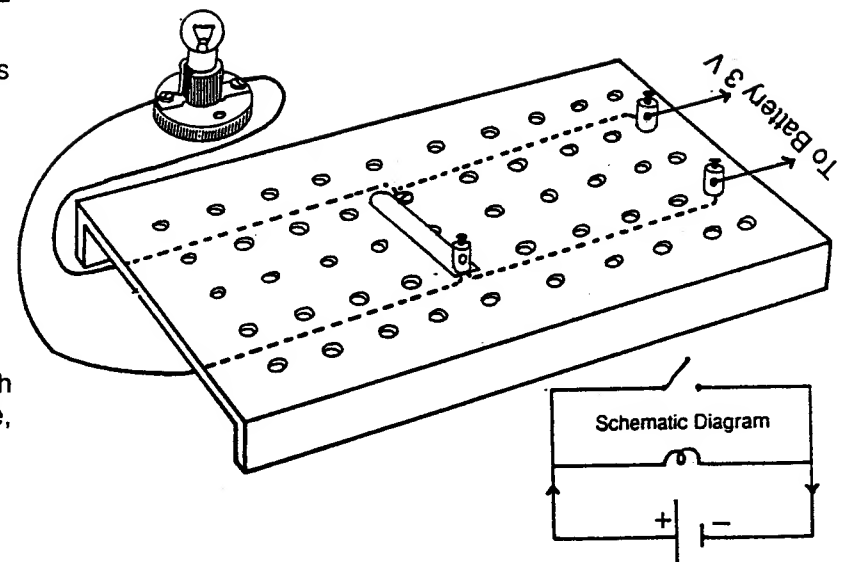
Parts: Baseboard, Bulb, Bulb holder, Moving Switch  
Contact-1, Terminals—3, Enamelled wire,  
Connecting wire, Battery—3V  
Screw : f—1

#### The Logical 'NOT' Circuit

Refer to fig. 45

Use the lamp assembly with the bulb screwed into the bulb holder per the last 2 experiments.

Fig 45



Fix the screw f, the moving switch contact and the terminal per figure. Make connections as shown. The switch is in parallel with the bulb and battery (see schematic diagram).

Follow these steps :-

- i. Leave the switch open — The bulb glows.
- ii. Press the switch. The bulb goes off.

The following truth table illustrates the above 2 conditions.

Switch	Bulb
Open (O)	Glow (1)
Closed (1)	No glow (O)

This circuit is called a logical 'NOT' circuit.  
The statements:

- i. When the switch is 'NOT' closed, the bulb glows.
- and
- ii. When the switch is closed the bulb does 'NOT' glow.
- are true

Caution : To prevent battery drain, do not depress the switch for more than a couple of seconds.

## EXPERIMENT 46

Parts: Galvanometer, Moving Switch  
Contact—2, Terminals—4, Enamelled  
wire, Sand paper, Connecting wires,  
Battery 1.5 volts. Screw: f—4.

### A Reversing Switch

Fix the screws f on the baseboard in the positions shown in figure 46. Insert the terminals into the holes in the 2 moving switch contacts and fix these in the position shown.

Make connections as shown, dotted lines indicating enamelled wire (Scrape enamel at points of connection using sand paper).

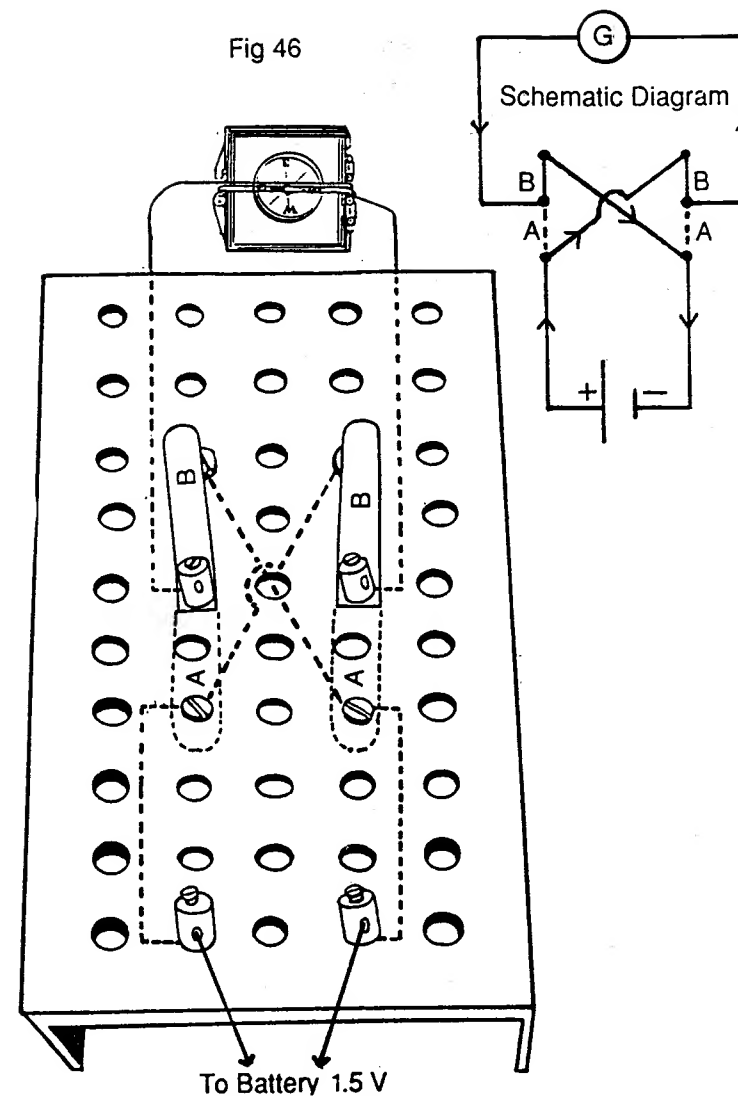
Turn the galvanometer so that the compass needle is in line with N—S.

Turn the 2 moving switch contacts to position A and depress them to touch the screws. The compass needle deflects in one direction.

Turn the moving switch contacts to position B and depress them to touch the other 2 screws. The compass needle is found to deflect in the opposite direction.

This illustrates the action of a reversing switch. Can you explain why.

Fig 46



## EXPERIMENT 47

Parts :Bar Magnet—2, Baseboard, Switch, Contact wire, Terminals—4, Connecting wire, Battery (4.5v)

### Motor Action (The Left Hand Rule)

Ref Fig. 47

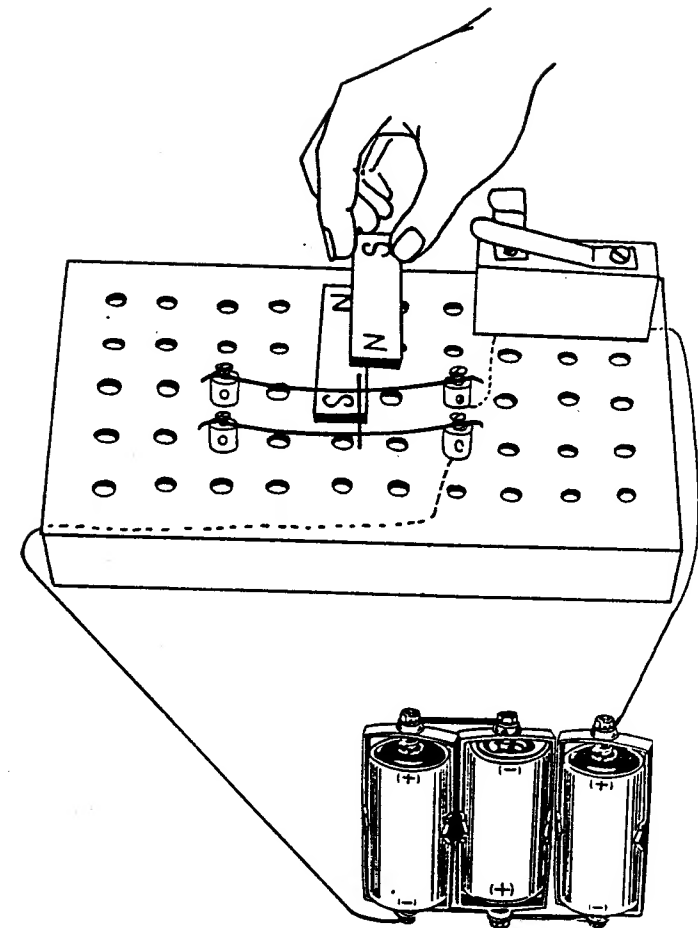
Fix the terminals to the baseboard in the positions shown.

Stretch two lengths of contact wire across the terminals looping the ends of the wire around the terminal screws as shown in the figure.

Place one bar magnet with its S-pole underneath the two wires, perpendicular to the wire lengths. The wires must be straight and free of irregularities. Gently press the middle of the wires with the forefinger till two troughs are formed by the wires (Ref figure). The bottom of the troughs should not touch the surface of the bar magnet.

Cut a length of contact wire (about 1"). Straighten this wire (roller wire) out by placing the wire on a sheet of paper placed on a flat surface and rolling it with a wooden scale (also flat!). Place roller wire across the suspended wires as shown. This wire should come to rest on the troughs.

Fig 47



### EXPERIMENT 48

Parts: Bulb, Bulb Holder, Switch, Connecting wires,  
Battery 4.5 V

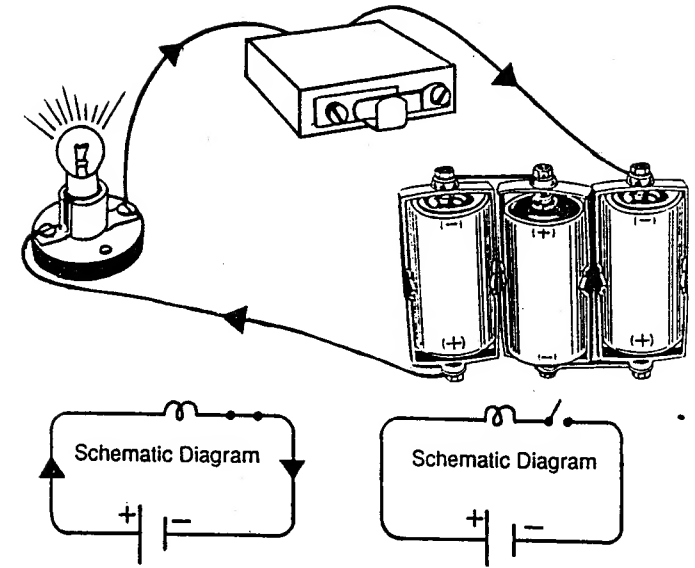
#### Heating Effect of an Electric Current

Screw the bulb into the bulb holder. Connect the bulb to the battery in series with the switch as shown in fig.48.

Switch on. The bulb glows. Leave the bulb 'on' for a couple of minutes. Feel the bulb with your fingers. It will feel warm. This explains how the electric current flowing through the bulb filament produces heat in the filament. An extension of this is the lighting effect causing the bulb to glow. Switch off.

Repeat the above experiment with 2 batteries (3v) and one battery (1.5v) What change do you observe and why?

Fig 48



## EXPERIMENT 49

Parts: Solenoid Switch, Baseboard, Long L rod, U Bracket, Fastening strip-white, Bulb, Bulb holder, Small sleeve 1/16". Terminals—4, Enamelled wire, Sand Paper (4.5 volts), Connecting wires, Battery.  
Screws: e—2, f—2.

### The Relay

Fix the solenoid to the baseboard with fastening strip and screws e. Fix the U bracket to the baseboard with the screws f. Insert the L rod through bracket holes, with the sleeve on the rod — fig. 49. Fix the 4 terminals, one (A) on the L rod end and the other (B) on the baseboard in the positions indicated. Fasten the switch (OFF) to the baseboard, and make connections with the bulb in the circuit.

Adjust the sleeve for the position of the L rod (slightly inside the solenoid shown in fig. 49. Ensure free movement of the L rod in the U-bracket.

Switch on. The L rod is pulled into the solenoid. This causes the two terminals in the bulb circuit to make contact and the bulb glows. Switch off. The bulb glows brighter than before. Can you explain why this happens?

In the above device, the contacts in one circuit are operated by change in conditions in another circuit. This device is called a relay.

Dotted lines indicate enamelled wire  
Bold lines indicate connecting wire  
Remove enamel thoroughly at points of connection, using sand paper

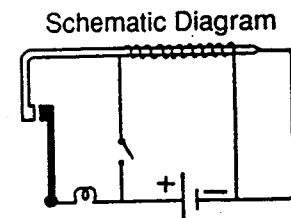
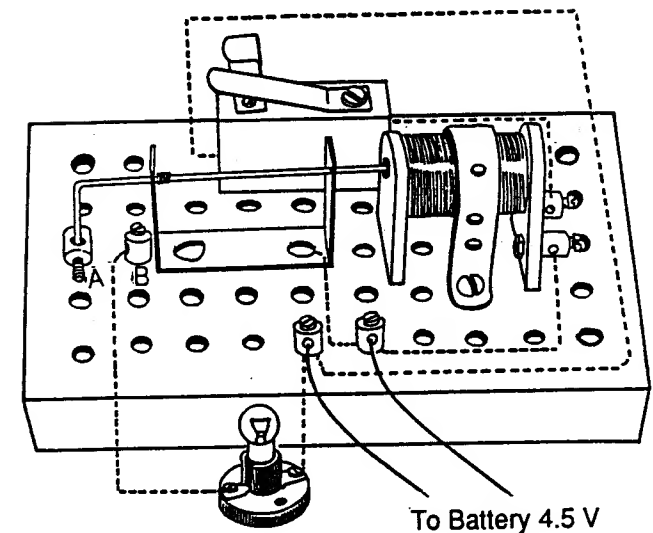


Fig 49

## EXPERIMENT 50

Parts : As in Experiment 49 (The Relay)

### The Relay II

The assembly is the same as shown in Experiment 49 except that the terminal B is displaced to the position shown in Fig. 50. Terminal A (fixed on the L rod) is between Terminal B and the U bracket. Move the sleeve on the L rod forward so as not interfere with the motion of the L rod, Ensure free movement of the L rod in the U-bracket. Connections are as shown in fig. 50. Pull the L rod backwards so that the terminal A touches the terminal B. The bulb glows. If not, ensure proper contact between terminals A & B till the bulb glows.

Switch on. The L rod is pulled inside the solenoid. This causes the two terminals in the bulb circuit to break contact and the bulb goes off. Switch off. Here, unlike in the previous experiment, the bulb is turned off on switching on the coil circuit.

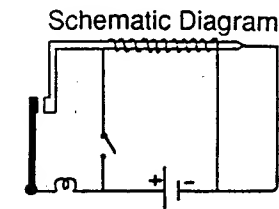
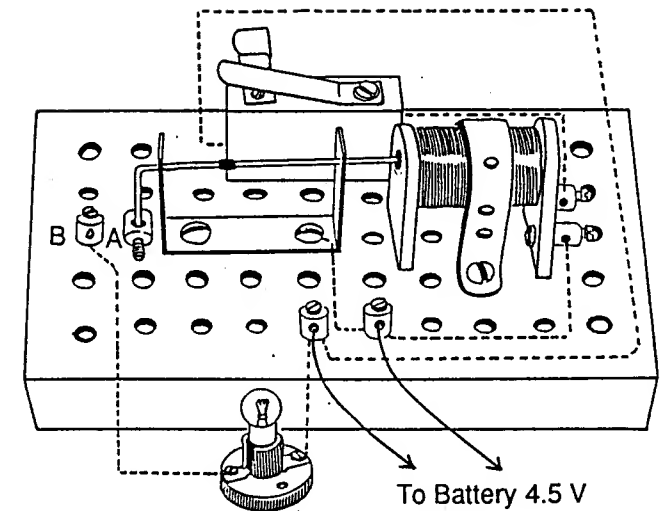


Fig 50

## EXPERIMENT 52

Parts : Solenoid, Core, Carbon rods—3,  
Diaphragm (under baseboard),  
Baseboard, Terminals—2 ,  
Enamelled wires, Connecting wires,  
Sand Paper, Battery (4.5 volts)

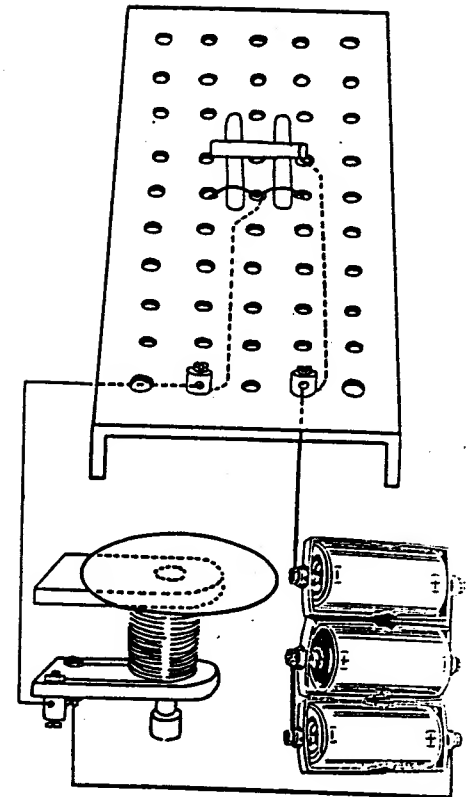
### A Simple Telephone

A telephone consists of 2 parts—the microphone and the receiver .

Remove the insulation thoroughly from a length of enamelled wire (about 8" long), using the sand paper. Fasten two carbon rods to the baseboard with this wire and connect the wire to one of the terminals. The third rod is tied with a **strand of connecting wire about 6" long** and this is connected to the other terminal—fig.52. This arrangement forms the microphone.

Insert the core into the solenoid hole, using a piece of paper, to provide a fairly tight fit. Place the diaphragm on top as illustrated. This arrangement forms the "receiver". The connections from the terminals to the battery through the coil are made with enamelled wire of fairly large lengths, the insulation being removed thoroughly at points of connection.

Fig 52





Tap the baseboard lightly. The tapping can be heard on the receiver kept near the ear. (Adjust the position of the core in the solenoid for distinct sound, sliding it in or out.) This happens because the disturbance due to the tapping causes the pressure between the carbon rods to change. The resistance in the circuit therefore changes causing the current to change. The changing current causes corresponding vibration of the diaphragm because of the changing electromagnet attraction.

### EXPERIMENT 53

Parts : Solenoid, Core, Baseboard, Hammer,  
Switch, Bell Gong, Gong spacer,  
Fastening strip-white, two holed  
spacer  
Terminals-3, Enamelled wire, Sand  
Paper, Connecting wires, Battery (4.5  
volts)  
Screw : e—2, f—4, Screw 'O'—1

#### The Hand-operated Electric Bell

Fix the gong to the baseboard with screw 'O' using the gong spacer. Fix the terminal to the hammer and fasten the hammer to the baseboard with screws f, using the two holed strip to raise the hammer. Fasten the solenoid to the baseboard with the strip and screw e (Loop the strip around as shown in fig ). Fix the switch to the baseboard as shown. Adjust the bell gong so that it is about 1/16" from the hammer terminal. Make connections per fig. 53, with the switch OFF.

Switch ON. Adjust the position of the coil so that the hammer contacts the gong. Switch off. The hammer springs back. When switched on, the hammer strikes the gong. The bell is thus operated with a switch. If the switch is operated rapidly and regularly, a continuous ring can be heard.

Fig 53

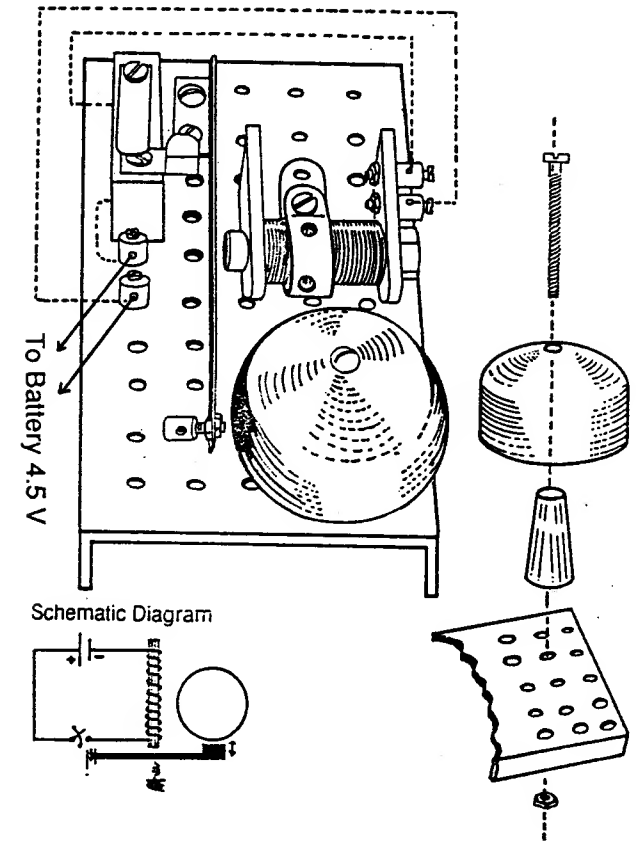


Fig 54

### Principle of Operation.

When the switch is closed, the solenoid is energised, magnetizing the core and the hammer is pulled towards the core, striking the gong. When it is opened, the core magnetism ceases and the hammer returns to its original position because of its tension.

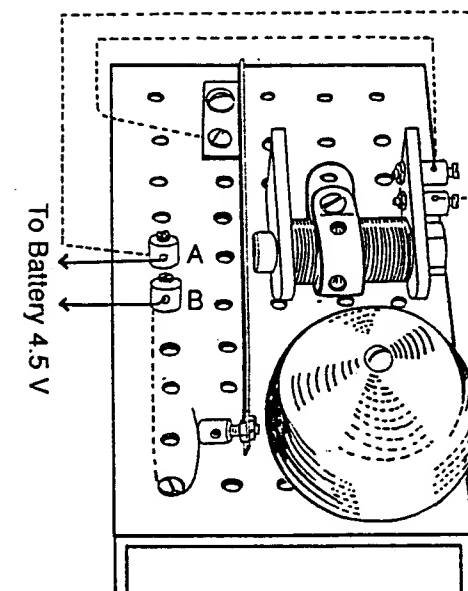
Dotted lines indicate enamelled wire  
 Bold lines indicate connecting wire  
 Remove enamel thoroughly at points of connection

### EXPERIMENT 54

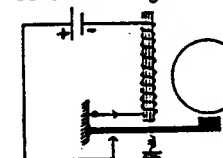
Parts : Solenoid, Core, Baseboard, Hammer, Contact Wire, Bell Gong, Two holed spacer, Gong spacer, Fastening strip—white, Connecting Wires, Battery (4.5 volts)  
 Screws : e—1, f—3, 0—1

### The Automatic Electric Bell

With the same assembly as in fig. 53 remove the switch from the circuit. Fix terminals A & B as shown. Fix screw 'f' in position shown, with the contact wire fastened under it, used as an 'interrupter' for the bell circuit. Make the connctions shown in figures 54. Adjust the position of the



Schematic Diagram



interrupter on the hammer terminal and the position of the electromagnet for good vibration of the hammer. The regular vibration of the hammer terminal against the gong produces a continuous ring. Disconnect the battery to stop ringing.

**Dotted lines indicate enamelled wire**

**Bold lines indicate connecting wire**

**Remove enamel thoroughly at points of connection**

**Remove paint around the hole of the hammer at the point of connection**

If the bell stops ringing, readjust the interrupter (contact wire) position.

### **Principle of Operation**

At start, the contact between the interrupter wire and the hammer terminal closes the electric circuit. The core is magnetised and the hammer is pulled towards it, sounding the gong. This action causes a break in the circuit at the junction of the interrupter and the hammer. Since there is no current through the electromagnet, the core is not magnetic. The hammer now springs back by tension to make contact again at the junction and thus close the circuit. This action repeats itself as long as the battery is connected, and a continuous ring is heard.

In the above experiment, the interrupter – hammer terminal contact replaces the switch of Experiment 53, and helps 'make' and 'break' the circuit rapidly and regularly,

## EXPERIMENT 55

Parts: Solenoid, Baseboard, Reel, Terminals—2,  
Scotch Tape, Contact wire, Plunger  
Enamelled wire, Connecting wire,  
Battery—4.5V  
Screw b—1, f—1.

### The Automatic Electric Hammer

Refer fig 55

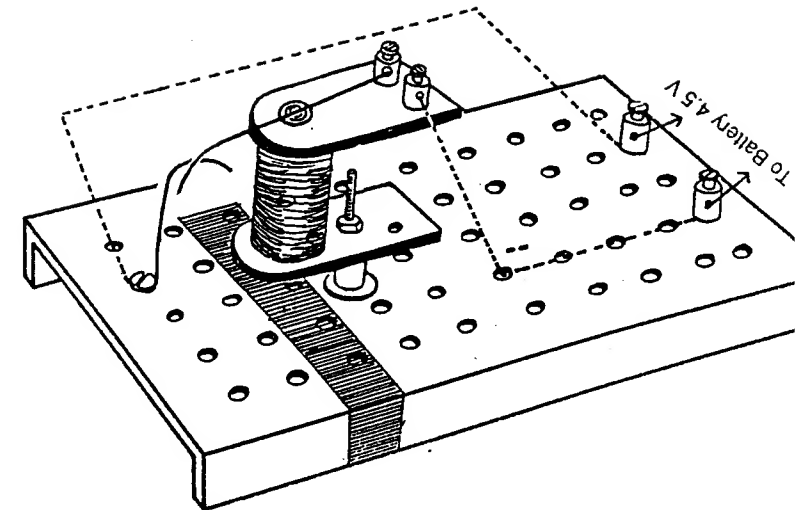
Stick a strip of scotch tape to the baseboard in the position shown in the figure. The tape should cover the five baseboard holes as shown.

Fix the solenoid to the baseboard with the reel as support using screw b as shown.

Insert the plunger into the solenoid hole with the plastic end up. The bottom of the plunger should rest on the scotch tape stuck to the baseboard.

Cut two lengths of contact wire each about  $3\frac{1}{2}$ " long. Fix one length of the contact wire to screw f and fasten the screw on the baseboard in the position indicated. Fix another length of contact wire to the solenoid terminal shown. The wire lengths from the

Fig 55



screw and the terminal should be about 3" each. Position the 2 contact wires as shown so that  
(i) the wire emerging from the solenoid terminal crosses the solenoid hole midway. This is to ensure that the plastic end of the plunger directly impacts the wire when the solenoid is energized.

(ii) The wire coming from the baseboard screw bends upwards and crosses under the contact wire mentioned in (i). Both wires must just make contact for the operation.

The wires mentioned in (i) & (ii) are called "interrupter" wires.

Make connections as shown in the figure.

### **Operation**

Adjust the interrupter wires so that the plunger travels up and down in a "hammer" like motion.

Can you explain how this device works?

Note: Ensure that the metal end of the plunger impacts the solid surface of the baseboard during its "up and down" motion.

## EXPERIMENT 56

Parts: Baseboard Switch, Bulb, Bulb Holder, Terminals—2, Enamelled wire, Connecting wire, Battery (3v)

### The Visual Telegraph

Refer fig. 56

The above device can be used to transmit any message visually, through a light bulb. The information to be transmitted is sent by means of a code known as the Morse Code which is used throughout the world in telegraphy. It was invented by an American named Morse. The code consists of simple dots and dashes used to represent the alphabets and numbers. It reads as under:

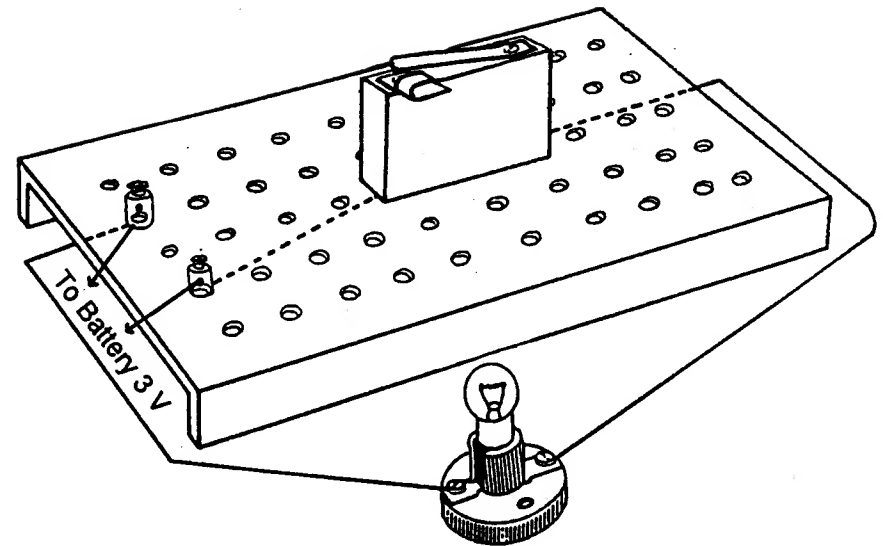
#### *Dots only*

e •  
i ••  
s •••  
h ••••

#### *DASHES only*

— t  
— — m  
— — — o

Fig 56



### DOTS and Dashes

a	·—	n	—
u	··—	—··	n
v	···—	—···	b
r	·—·	—·—	k
w	·— —	—·—	g
l	·—··	—·—	y
f	··—·	—·—	q
p	·— —·	—··—	x

c—·—·  
j·— — —  
z— — —·

1	·— — — —	—····	6
2	··— — —	— —···	7
3	···— —	— — —··	8
4	····—	— — — —·	9
5	·····	— — — — —	0

From the above, the following simple words would spell :

Tom — — — — — Tie — ·· ·

His ···· ·· ... Cat —·—· ·— —

368 ···— — —··· — — —··

10 ·— — — — — — — — — —

To assemble the telegraph, fix the switch to the baseboard as shown. Make connections as shown in figure, switch in series with bulb and battery.

Operation : Press the switch for an instant. This causes the bulb to glow momentarily and represents a 'dot' (·). Press the switch for a longer time. This causes the bulb to glow for a longer duration and represents a dash (-). An observer within the visual field of the bulb can interpret the message and record it on paper. Thus, words and sentences can be transmitted by leaving a long pause between words.



## EXPERIMENT 57

Parts : Baseboard, Paper clips—3,  
Enamelled wire, Connecting wires,  
Sand Paper, Terminals—4, Long L  
rod, Bulb—2, Bulb Holder—2, Battery-  
3V Screws: f—3

### The Nerve Tester

Ref fig — 57

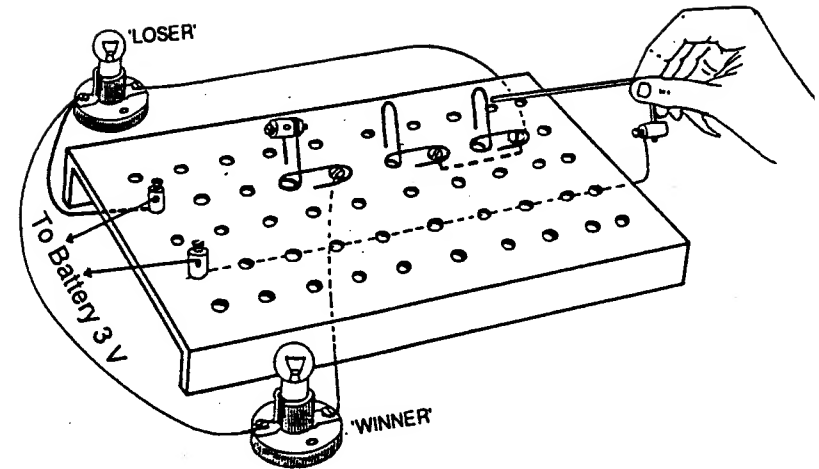
Screw the bulbs into the bulb holders.

Bend the tabs on each paper clip till they are at right angles to each other.

Fix the clips to the baseboard, the shorter tabs secured to the baseboard with screws f in the positions shown so that the longer tabs are in line with each other. Secure a terminal with the nut to the end of the longer tab on the extreme clip, as shown.

Insert a terminal into the shorter end of the long L rod and screw it in place. Make connections as shown in fig.

Fig 57



### **Operation**

Pass the long end of the L rod through the loops in the two tabs of the first 2 clips as shown in fig. without touching them.

Try to touch the terminal on the extreme clip without touching the other two. If you succeed you win and the 'winner' bulb glows. Otherwise you lose, and the "loser" bulb glows.

If you are steady, you will be able to make only the winner bulb glow.

### **EXPERIMENT 58**

#### **How Innovative are you ?**

Can you assemble a Nerve Tester that is not as difficult as the one in Experiment 57.

Hint : Use one clip only in the "Loser" Bulb Circuit.

## EXPERIMENT 59

Parts : Coil, Core, Baseboard, Rotor, Rotor rod, U bracket, Fastening strip-white, Switch, small sleeve 1/16"—2, Terminals—2, Enamelled wire, Connecting wire, Battery 4.5 volts.  
Screws : e—2, f—2.

### The Simple Electric Motor

#### 1. Rotor Assembly on U bracket

Fix the U bracket to the base with screws f. Push a sleeve on the rotor rod a little beyond the threaded length. Insert the rod through the bracket holes and push the other sleeve on the far end of the rod. Screw the rotor on the rod — fig. 59. Check for free rotation.

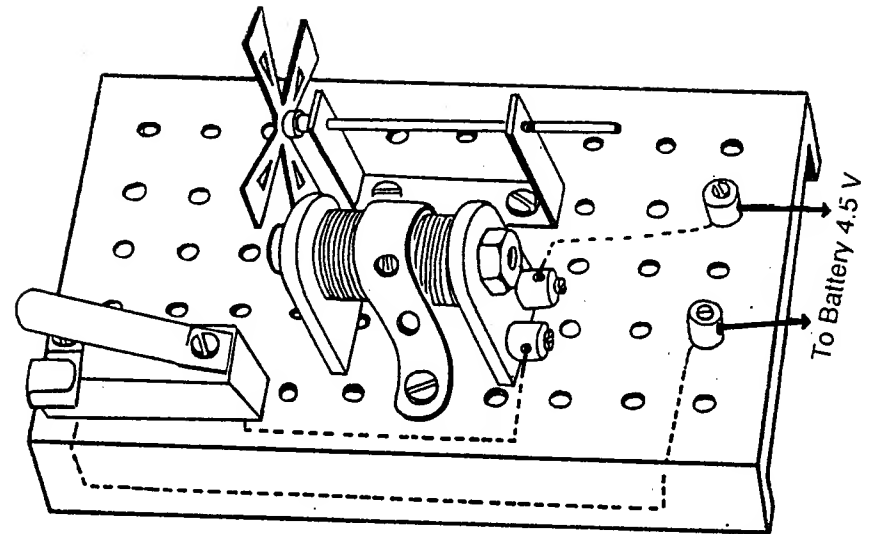
#### 2. Switch Assembly

Fix the switch in the position shown.

#### 3. Electromagnet Assembly

Insert the core into the coil and lock it in position. Fix the coil to the baseboard with the fastening strip and screws e in the position shown in fig. 59. Make connections as indicated, with the switch OFF.

Fig 59



### Adjustment and Operation

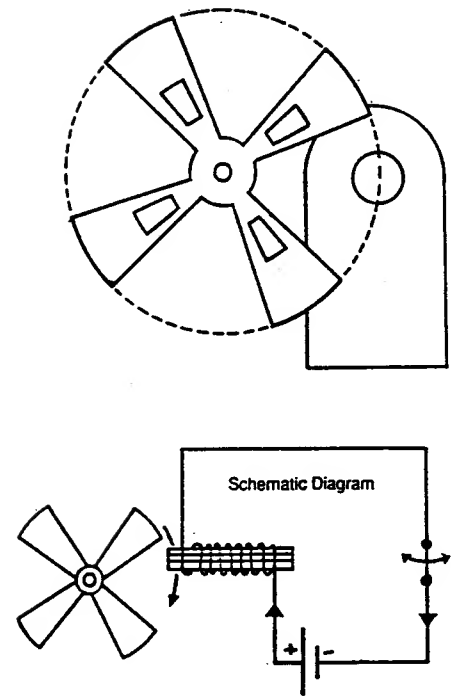
Move the rotor through a revolution and check for a distance of about  $1/16$ " between the core and the blades of the rotor as they pass the core.

(This gap may be adjusted as required by moving the sleeves on the rotor rod, or by moving the electromagnet towards or away from the rotor). Check that the rotor blade edge bisects the core for each quarter of a revolution. Turn the rotor to such a position that one of its blades is slightly nearer the core than the other, as in fig. 59A. Switch on. The blade near the core is pulled towards it, because the electro-magnet is energized through the switch. It continues to be pulled as long as the switch is closed. Switch off. The pull on the blade ceases. Again adjust one of the blades to be nearer the core than the other. Switch on. This blade is again pulled towards the core, causing movement. It remains pulled towards the core as long as the switch is closed. Switch off. The pull ceases.

Again, with the position of the rotor as in fig. 59A, operate the switch like a key at regular intervals (ON and OFF). It is observed that there is an erratic rotation, depending on the operation of the switch. The rotor is thus operated by a switch in the electromagnet circuit. Switch off.

**Dotted lines indicate enamelled wire**  
**Bold lines indicate connecting wire**  
**Remove enamel at points of connection**

Fig 59 A



## EXPERIMENT 60

Parts : Coil, Core, Baseboard, Commutator, Rotor, Rotor rod, Fastening strips—2, U Bracket, Small sleeves, 1/16"—2, Terminals—2, Contact wire, Enamelled wire, Connecting wires, Battery( 4.5v.) Screws : e—2, f—4

### The Automatic Electric Motor

#### 1. Commutator Assembly

Insert the contact wire (about 6" long) through the commutator holes in the sequence illustrated, and finally push the remaining length of wire through the central commutator hole—fig.60.

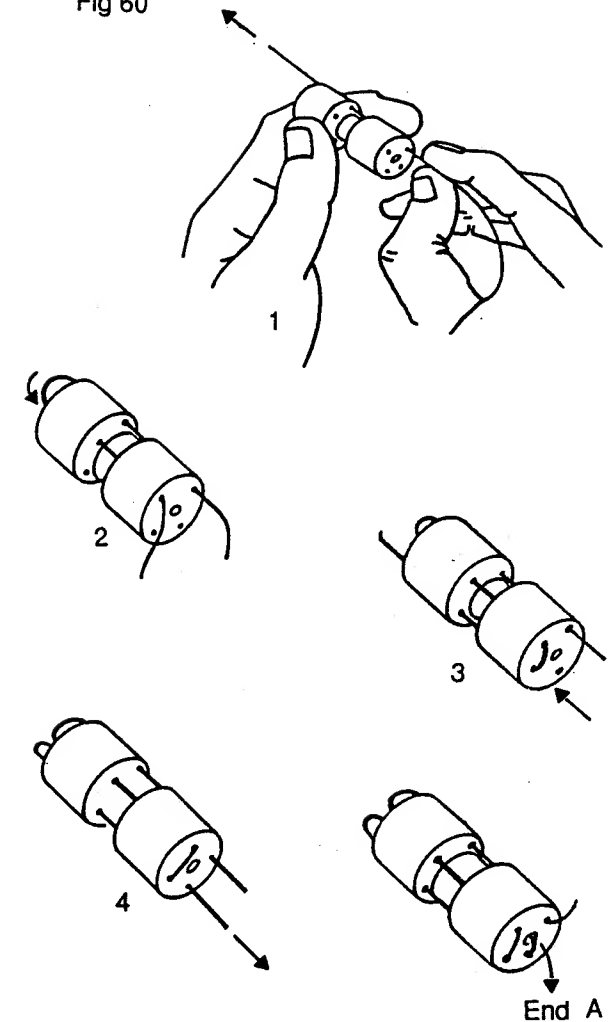
#### 2. Rotor Assembly on U bracket

Fix the U bracket on the baseboard with screws f. Push a sleeve near the threaded end of the rotor rod. Hold the commutator within the U bracket. Push the rod carefully through the bracket holes and the central commutator hole with end A of the commutator facing the threaded end as it passes through. Push another sleeve on the rod, as indicated. Screw the rotor on the rod—fig. 60B.

#### 3. Brush Assembly

Fasten a length of contact wire (about 2 1/2") to screw f fixed in the position shown in fig. 60B. This serves as the brush contact. Fix the colored fastening strip fairly tight on the baseboard as shown, with screw f. This strip serves to adjust the pressure of the brush on the commutator contacts.

Fig 60



#### 4. Electromagnet Assembly

Insert the core into the coil and lock it in position. Fix the coil to the base with the fastening strip and screws e. Move the rotor through a revolution and check for a distance of about  $.1/16''$  between the core and blades of the rotor as they pass the core. The sleeves on the rotor rod or the position of the electro-magnet may be adjusted to provide this gap.

Check that the rotor blade edge bisects the core for each quarter of a revolution, as this is one of the conditions for efficient operation of the motor. (fig. 60A).

Make the dotted line connections (enamelled wire) as indicated in fig. 60B.

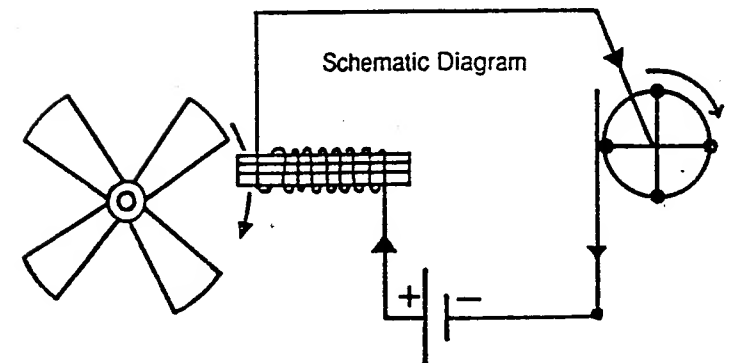
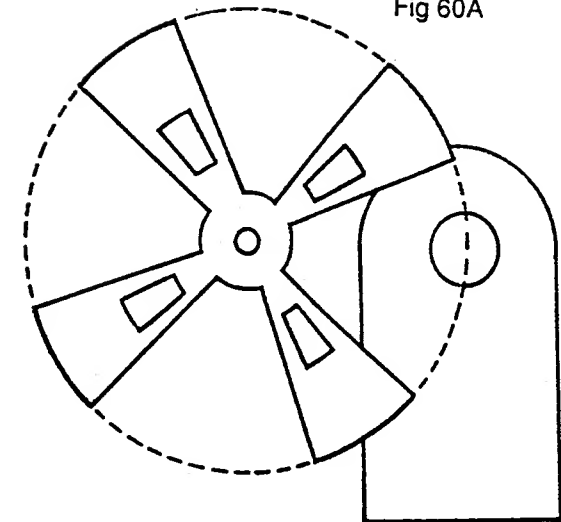
#### Adjustment and Operation

**Brush:** Straighten out the brush wire carefully, with the adjusting strip turned away from the brush. Adjust the brush for light contact on the commutator wires.

**Rotor:** Hold the commutator and carefully turn the rotor about the commutator such that when a contact is made between the commutator and the brush wires, the rotor position is as shown in fig 60A.

Check again for free rotation of the rotor against pressure of the brush.

Fig 60A



Connect the battery to the motor terminals (bold lines) and spin the rod with the end sleeve, which serves as a grip.

If adjusted properly, the motor will run with reasonable speed. Fine adjustment of the commutator with respect to the rotor, and brush pressure will improve the running of the motor. If the brush pressure is too much the motor slows down. Oil the bearing surfaces on the U bracket.

### Principle of Operation

The principle of operation of this motor is not to be associated with Experiment 47 on Motor Action. This motor works on the principle of magnetic attraction. When the brush makes contact with any of the 4 commutator wires, it actually closes the electric circuit to the device, i.e., current flows from the battery through the coil, bracket, rotor rod, commutator wire and the brush and finally back to the battery. This energizes the electromagnet, which attracts the rotor blade near it. The blade thus moves and causes the commutator to rotate, breaking the circuit. The rotor continues to move by inertia, and the next rotor blade is pulled because of another contact made at the junction, causing

further rotation. The motor thus operates automatically. Since there are four contacts in the commutator, the electro-magnet is energized four times a revolution, and each time it attracts a blade towards it, maintaining the rotation. The commutator thus serves as an automatic switch to make and break the circuit rapidly and regularly.

To stop working, disconnect the battery.

Remove enamel at points of connection.

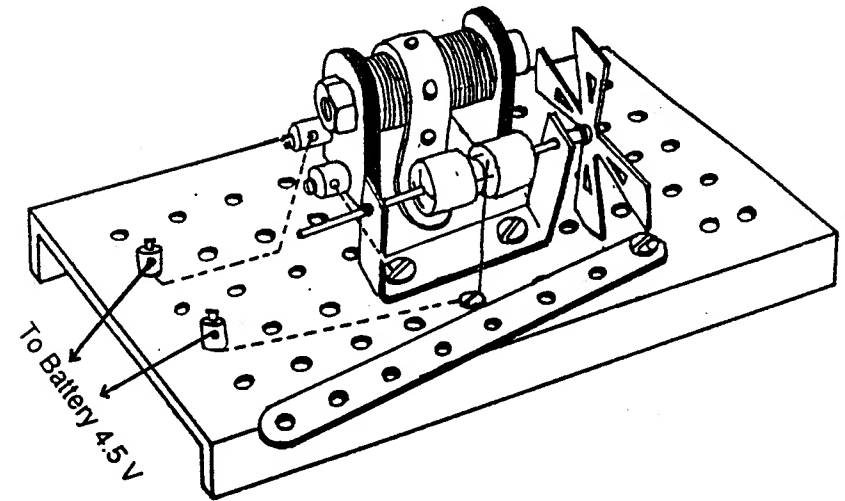


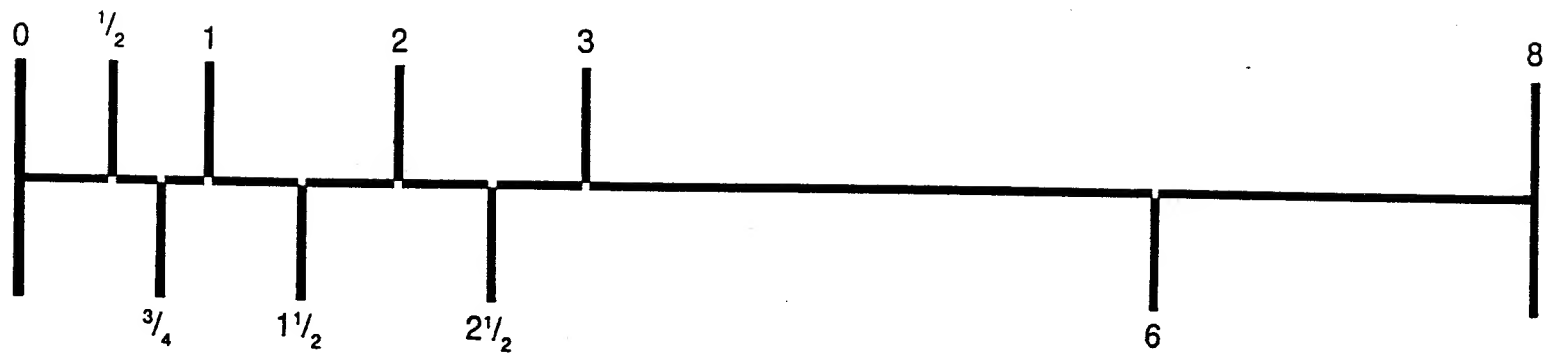
Fig 60B

Lengths in inches

$\frac{1}{16}$

$\frac{1}{8}$

$\frac{1}{4}$







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